J. Nelson Spaeth

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VOL. 37 APRIL 1939 No. 4

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EDITORIAL

What Lies Ahead for the Forestry Graduate of 1939

TO say that these are troubled and difficult times is only to repeat a hackneyed and trite phrase. Yet these are troubled times, and difficult too, for those about to embark on a professional career, as well as for those who have already begun such a career. For the first time in five or six years, conditions will be found to be about as troubled and difficult for forestry graduates as for graduates in other professions. The forestry graduates of 1939 will soon arrive at the end of the road they have been following, more or less intently, for four years. There they will find many, many trails, some leading ultimately to success, others ultimately to failure, still others leading ultimately to oblivion. Despite the fact that these trails have been traveled by all preceding generations of forestry graduates, and despite the fact that those who have traveled them have left many records of the equipment needed to make the journey, of the hazards, the dangers, the risks along the trail, of safe resting places, and of many other conditions, these seem to be little used by those about to begin their journey.

In about 1933 the number of men to graduate in forestry became abnormally large, but at that time this created no special problems because practically every graduate readily found employment. Even then, however, forestry educators were somewhat concerned because it was known to all that the cause of the large enrollments would not and could not continue indefinitely. When the size of the graduating classes first greatly increased about two years ago, the much expanded conservation program was contracted and curtailed. Today even the "regular" appropriations of many government departments seem to be in some jeopardy because of the tremendous deficits accumulated during the peak of the emergency program. What then are the almost fourteen hundred foresters soon to be graduated from American universities to do; to whom can they turn for employment?

There is no general or simple answer to these questions. Of course, the immediate problem would be solved if the emergency conservation program were again enlarged and expanded. This, however, would not be a permanent solution; it would indeed only prolong the agony and would lead to still more difficult future problems.

Employment opportunities in any professional field are immediately reflected in university enrollments. If employment opportunities in forestry were abnormally increased, the now falling enrollment curves would again swing upward. As a result the whole cycle would be repeated which would be unfortunate indeed, especially for the young men who would be attracted to forestry only because of abnormal employment opportunities.

At the moment it appears certain that the Civil Service Commission will hold the Junior Forester, the Junior Range Examiner, and other junior examinations this spring. As a result of this examination, a number of the graduates of the class of 1939 will undoubtedly receive appointments. It is highly probable, however, that only a portion of the men who take these examinations will pass them, and unless the method of marking the examinations is somewhat different from that formerly used, not all of the men passing the examinations will secure appointments. The men who do not pass one of these examinations have few if any prospects to secure anything but temporary work from the Forest Service or other federal agencies. The men who do

pass but with a low mark must be realistic—nothing is to be gained and much is to be lost by waiting too long for an appointment which may never materialize.

Undoubtedly a few men also will find employment with various state forest services. In most, if not all such cases, the individual will have to be a resident of the state in which employment is secured. Therefore, forestry graduates have little to gain by writing promiscuously for employment to conservation departments of other states. At best, the number of men absorbed by state forestry and conservation departments will be relatively small.

Where can the men who do not secure employment with federal or state conservation agencies turn for employment? The most obvious alternative is the lumber industry; but the possibility is remote that this industry, large as it is, can and will absorb in a professional or even in a semi-professional capacity the number of men available. A considerable number of forestry graduates should, nevertheless, be able to find "jobs" in the lumber industry. The writing of numerous letters of application ordinarily helps little in securing such jobs. Little is to be gained by emphasizing the fact that the individual is a college graduate. The only really important considerations are that the individual is willing to work, able to work, and that he appear on the scene at the time when there is a job to be done.

Some of the 1939 graduates will undoubtedly wish to consider the opportunities and advantages of extending their college training. Unfortunately, about the first thing many students, who having completed an undergraduate course and are unable to find immediate employment, think of is graduate study. Despite all that is being said in support of the advantages of graduate study, the fact remains that not all those who by "hook or crook" finally complete the requirements for a baccalaureate degree can successfully carry the work for a graduate academic degree. Furthermore, not all those who can carry graduate work successfully will profit greatly by so doing.

Before any forestry graduate embarks upon a program of graduate study, he should consider carefully his objectives, his inherent intellectual capacities (undergraduate and high school scholastic records are splendid indices), his love for learning, and his personal traits and characteristics. Unless he does he is apt to experience still greater disappointments and disillusionments in the future. These may be even worse than those he is experiencing at the moment or has experienced in the past.

On the whole, opportunities for the employment of the foresters of the class of 1939 appear none too bright. The men graduated in 1939 may, however, advance the cause of technical forestry infinitely more than those men who graduated during those halcyon days when jobs in emergency conservation work practically went begging. Under such conditions graduate foresters invariably followed the line of least resistance. There was no incentive or need to extend the marginal fringe of employment. Many men even left the marginal fringe of employment for what appeared to be more permanent and less hazardous public employment. When the history of forestry in the United States is written, it is, in fact, not unlikely that the period during which the emergency conservation program was at its height will be regarded as one of the most sterile priods in American forestry history in so far as professional development is concerned.

The forestry graduates of 1939, perforce, will be compelled to seek out, develop, and create jobs. The jobs that escaped notice four or five years ago will doubtless be ferreted out and filled by forestry graduates. Because of the ability, the energy, and the force of the individual or individuals filling them, some of these jobs will become responsible positions exerting a strong influence on the rate of acceptance of sound forestry practices by private timberland owners or on the extension and preservation of markets for wood. If this comes to pass, then the graduate of 1939 may indeed make one of the most significant contributions yet to have been made to American forestry practice.

The forestry graduates of 1939 do not want an obituary at this time. Many are men of ability, some are energetic, with few exceptions, all are hopeful. During the uncertain days that lie ahead, they will not be fighting alone for recognition and advancement. Squarely behind them will be foresters in general, the schools that graduated them, and the Society of American Foresters. Whenever and wherever these groups can be of help, help will be freely given. To establish themselves, the forestry graduates of 1939 must exert themselves much more than did the graduates of the past five or six years; they must have patience, courage, and perseverence. That some will be outstandingly successful is a foregone conclusion. May each and every one find some task commensurate with his ability

RALPH CLEMENT BRYANT
1877-1939

By HENRY S. GRAVES
Yale School of Forestry

RALPH CLEMENT BRYANT, F.E., ScD., professor of lumbering at the Yale School of Forestry, died after a short illness on February 1, 1939. He was one of the stalwart group of foresters who had entered the profession at the turn of the century. For more than thirty-two years he had directed the work in logging and lumbering at Yale and had won high distinction as a forester, educator, author, and leader in his special field.

Professor Bryant was born in Princeton, Ill., in 1877. His preparatory education was in the local high school, and he entered the University of Illinois in 1896. After two years he transferred to Cornell University at the time of establishment of the New York College of Forestry under the direction of Dr. Bernhard E. Fernow. Ralph Bryant was the first graduate of the College in 1900, receiving the degree of Forest Engineer.

It was quite natural that Ralph Bryant should choose forestry as his profession because there was a family interest in trees and planting of trees. His father, Arthur Bryant, owned extensive nurseries and conducted experiments in tree planting in cooperation with the University of Illinois. His grandfather, Arthur Bryant, a brother of the poet, William Cullen Bryant, published in 1871 a book entitled *Forest Trees for Shelter, Ornament, and Profit*, with a subtitle, "A Practical Manual for their Culture and Propagation." This book of 247 pages is of great interest as a contribution to the national movement for tree planting at that period.

After graduation Ralph Bryant worked for a year with the Forest, Fish, and Game Commission of New York. He was then called to service in the Bureau of Forestry of the Philippine Islands under Major George P. Ahern, and within two years was promoted to the position of assistant chief. At that time American control of the Philippines had been in effect only a few years and the laws and policies for administration of the public forests were still in the process of development. Bryant participated in this pioneer undertaking with special responsibilities in the work of organization and administration of the forests. He was on the ground when American methods were introduced for logging and manufacture of the heavy hardwood timber of the Philippine Islands. He had a hand in the formulation of timber sale policies and of the regulations to control the work in the field, an experience of value to him in his later work in this country. This chapter of his life and the extent of his contribution to the early forestry work in the Philippines has never been fully told.

He returned to the United States in 1905 on account of illness in his family, and worked for a time in the Forest Service. He was brought to the Yale School of Forestry in 1906 to take charge of the work of instruction in the field of logging and lumbering. At that time the lumber manufacturers of the country had contributed to an endowment fund in the School for work in "applied forestry and practical lumbering." This was an undeveloped field of education. Bryant was selected because he had already given evidence of special qualifications for such a constructive undertaking. He recognized that the task involved instruction of students in the engineering, economic, and business problems of a large and diversified industry, and at the same time the preparation of the men for the progressive adjustment of procedures in logging to the needs of forest production and management. This could not be accomplished by class work alone; it required practical field training as well. The same principle applies in preparing students in organized forest management. It was in order to meet this problem that the plan was adopted to transfer the work of the students in the last part of senior year from New Haven to the field for work in lumbering and organized management.

For 13 years this field work was conducted each year on a different tract of land in the south, through special arrangement with the owners. Since 1920 the school has conducted a camp at Urania, La., on the property of the Urania Lumber Company, with Professor Bryant in charge of the work of lumbering and Professor H. H. Chapman in charge of forest management. It has been the custom, further, to spend some

Ralph Clement Bryant

time on the forests and at the mill plant of the Crossett Lumber Company at Crossett, Ark. Professor Bryant for many years had been adviser to this company in developing their undertaking on a sustained yield basis.

Professor Bryant was called upon from time to time to participate in public activities both in forestry and industry. During the war he was brought into service to aid the Lumber Committee of the War Industry Board in the procurement of lumber and other timber products required for war purposes. He was President of the Society of American Foresters in 1920 and 1921. He served as a member of the Council of the Society for a number of years and at various times participated in the work of its committees.

Professor Bryant was patient, persistent, and thorough in his scholarly work, with unusual ability to acquire and use knowledge. He had the capacity to search out essentials of a problem and to determine principles to govern his conclusions and action. This quality and his wide information created confidence in his judgment and contributed largely to his leadership in his field.

His best known writings are his books entitled *Logging,* and *Lumber,* which are widely used in forest schools and elsewhere. He had to his credit a number of important bulletins and he contributed many articles to forestry and industrial journals. In the more recent years he was specially interested in studying the movement of prices of forest products, domestic and foreign markets, and other basic economic features of the lumber industry. He had in contemplation further writing in this field. He was greatly interested also in the problem of developing markets for inferior grades of timber. He took a prominent part in organized effort in southern New England to promote the use of wood for fuel in the home and the small industrial plant. He had been impressed by the various devices for use of inferior grades of timber in Germany and other European countries on the occasion of his work abroad in 1935 under a grant of the Oberlaender Trust.

Professor Bryant will be remembered for his fine personal qualities, as well as for his professional achievements. He was a man of cultivation, widely read and interested in affairs. He had a sparkling sense of humor that made him a delightful companion in the woods or elsewhere. He was unassuming and consistently modest of his accomplishment and honors. He was awarded the honorary degree of Doctor of Science by Middlebury College in 1928, but was the last person ever to refer to it. He was keen in his appraisal of men. Industrious himself, he looked for it in those working under him. He was tolerant in his judgments of men, but he was sternly impatient of pretence in any form. His unfailing consideration of others was one of his most prominent and attractive characteristics.

His passing will be felt by his colleagues in forestry and by the great number of friends who were bound to him by attachments of mutual sympathy and confidence.

DEDICATION AND PRESENTATION EXERCISES OF THE AUSTIN CARY MEMORIAL

Saturday, January 14, 1939, 9 a.m.

Dedication of the Austin Cary Memorial at the Austin Cary Memorial Forest of the Florida Forestry School (8 miles north of Gainesville, Fla., on the Starke road).

Presiding: G. H. Lentz, Chairman, Southeastern Section, S.A.F.

Invocation: Rev. W. T. Halstead, Baptist Church, Lake City.

Appreciation of Dr. Austin Cary.
A. B. Hastings, U. S. Forest Service.
W. T. Neal, President, Southern Pine Association.

Presentation of the Memorial to the Society of American Foresters.
Director H. S. Newins, Chairman of the Memorial Committee.

Acceptance of the Memorial for the Society, and Transfer of its Custody to the University of Florida.
Dr. C. F. Korstian, President, Society of American Foresters.

Acceptance of the Custody of the Memorial.
Dr. John J. Tigert, President of the University of Florida.

Inspection of the Austin Cary Memorial Forest.

INVOCATION[1]

ALMIGHTY God, Eternal Father of mankind, remembering that every good thing cometh down from the Father Above, we would bring to Thee our tribute of praise and thanksgiving.

We bless Thy name for the bountiful gifts we daily receive from the bosom of the earth which Thou hast made, for the unchanging law of the harvest in its returning seasons, and for our stewardship to dress and keep its forests and gardens.

We thank Thee for the men of vision whose courage and patience have discovered to us Thy laws. We assemble this day in grateful memory of Austin W. Cary, a diligent searcher for truth. We call to mind his many years of devotion and service. Grant that his life and his achievements may become an abiding inspiration to all who knew and loved him. May his mantle fall upon the shoulders of others who shall be able and worthy to lead us still farther on.

We would remember our responsibility, to use for the good of all mankind, and for the glory of God, Thy gifts and blessings and also the heritage of knowledge and power which has been handed to us by those who have led the way through toil and difficulty.

To this end bless us as we consecrate ourselves to the task of adding other stones to the permanent temple of truth. Help us to extend the range of our vision and interest so that, as we are given new knowledge and power, we may become a blessing to all men.

So, do Thou bless our State and Nation and every agency in them which seeks to make a better world. While others choose the low and selfish ways, help us to walk the high roads.

Give continued success to this Society and its friends in their worthy undertakings.

Bless with Thy divine leadings this College as it seeks to discover and to disseminate a knowledge of the better ways for sustentation and enrichment of life.

Bless Thou, we pray, this great University of which the College is a part, its president, its faculty, its alumni, and its student body.

May the light of Thy Countenance ever cast its rays upon our pathways and may we walk in that light till we see the dawning that shineth more and more unto the perfect day of the full achievement of all our worthy ambitions and of Thy purposes for us.

These things we do humbly beg in the name of Him who is our Saviour and Lord. Amen.

[1]Transcript of prayer by W. T. Halstead, Pastor, First Baptist Church, Lake City.

APPRECIATION OF AUSTIN CARY

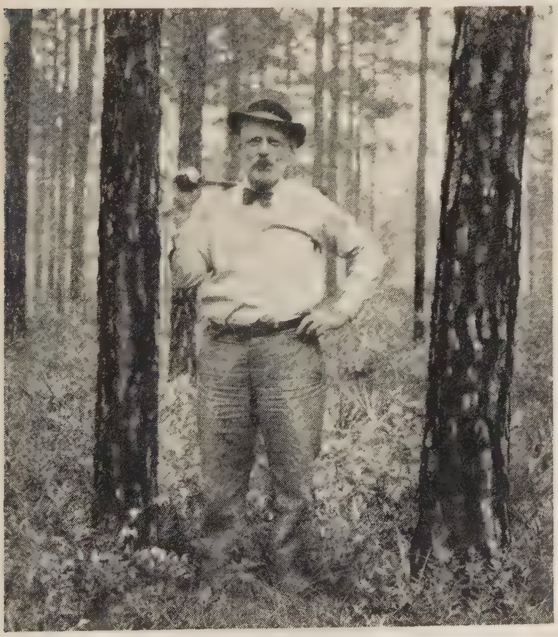
By A. B. Hastings
U. S. Forest Service

WE are here to dedicate to Austin Cary and his work a living memorial of trees. Marked by the granite of his native state, there is here mingled the spirit of the northern spruce with that of the southern pine.

These trees are a symbol of those many others which, by reason of his inspiring labors are now growing with increased vigor for the health and prosperity of the individual and of the Nation.

It is altogether fitting that our memorial should be located in the region of his keenest professional interest and that the University of Florida for which he forecast a major role in the forestry of the future, should be its guardian.

This memorial has been planned and completed with spontaneity and joy because the man whom it honors, in a long life of earnest and happy labor, was singularly free from all seeking for self-appreciation. When he retired and letters came to him from all parts of the country expressing high praise of his many achievements in the field of American forestry, he was taken completely by surprise.



Austin Cary

To him, with a well-rounded career of good works, and with no economic pressure for continued labor, leisure and idleness had no appeal. At this time he wrote that his work had never interested him more—a splendid tribute to the man and to forestry.

Austin Cary was a scholar. Graduated from Bowdoin College with honors in 1887, and later the recipient of the degrees of Master of Arts and Doctor of Science from that institution; a graduate student at Johns Hopkins and Princeton; a teacher of forestry at Yale and Harvard; three times a visitor and student of forestry in Europe; a Fellow of the Society of American Foresters (the highest honor it can bestow); an intellectual leader; a distinguished writer; yet how simple, practical, and modest was the application of his learning.

He was a seeker for the truth with the unassuming approach and open mind which made available to him the experience of common laborer and high executive alike, for application in supremely common sense fashion to the everyday problems of forest land development and utilization. He was decidedly an individualist, but he pursued his straightforward course with the respect of his associates, including those with whom he may have fundamentally differed.

A keen observer, he carried on his own multitudinous investigations, the results of which were promptly utilized. His tools were few, his methods were simple, he asked none to follow blindly, but his influence on timberland owners toward improved forest practices was second to none.

Austin Cary was for a quarter of a century an honored member of the U. S. Forest Service. He was engaged in forestry for more than 42 years. Upon one occasion a representative of naval stores interests of the South came to Washington with the earnest plea to the Chief of the Forest Service that the South be given more Austin Carys. The request was instantly recognized as sound, but there was only one Austin Cary—and he still lives in his work, an inspiration and a challenge.

RAMBLING THOUGHTS ON THE ACTIVITIES OF THE LATE DR. AUSTIN CARY

By W. T. Neal
President, Southern Pine Association

WE are gathered here today to pay tribute and give honor to the man who gave his life's work to the perpetuation of forest resources of this country and for the benefit of mankind. He did a good job and never assumed that he nor anyone else had a monopoly on all the knowledge of forestry, but I do say he was outstanding in his profession.

He was modest, kind, considerate, and a tireless worker. He was progressive from every viewpoint. My acquaintance with him dates back about twenty-two years, and from the very first I learned to love him and enjoy his many high qualities of character. Many times he was entertained in my home, and the whole family always enjoyed him. He was a man of wide experience and could converse on almost any subject for awhile, but the conversation would usually drift into forestry before he went very far.

Many times did he go out on the lands of our company and express admiration at the wonderful state of forestry in this country. On one of his trips I remember he stood up with admiration and threw his hat on the ground and exclaimed in most emphatic language that if this scene were in Germany the people would crowd the boats to go over there and see it, so why don't they come and see what nature has provided? The scene he was looking at was longleaf pine seedlings just out of the ground, from that on up to mature timber, all standing on the same area.

Many years ago he came into my office one day, and as we sat and talked he says, "Let's go out into the woods," so we went, and he established there a growth plot, made his record on some yellow copy paper. When he came back he laid the sheets on my desk without any comments and left town that afternoon or the next morning. About two years later he came in one day and after saying "good morning" he says, "Where is the record of my growth plot?" I did not have any idea where it was, but I called the stenographer and told her to get Dr. Cary's records, so she produced it very promptly, much to my surprise, as I had no idea what had become of it. He then said, "Let's go out and take another measurement," so we went and remeasured, and he expressed extreme gratification at the growth results.

After that he established a number of other growth plots, which we are at this time observing and in a crude way perpetuating, but not as Dr. Cary would have done. Eight or nine years ago he came over to visit us and suggested that we do some thinning in our young pines. We organized a crew, of which he took charge, and thinned some 6,000 acres, covering a period of from two to three weeks.

We knew he was employed and paid by the U. S. Forest Service, but in appreciation of his services we tendered him a check for $75 or $100, I do not remember which, which he promptly handed back informing us we owed him nothing and that he was paid by the U. S. Forest Service, but if we wanted to make that contribution to the U. S. Forest Service, change the check and he would be glad to turn it over to them, which we did.

While he was a native of Maine and received his education and early training in the East, his heart was in the South, and when he received notice from the Forest Service that he would be retired, he made this remark, "If they do retire me, I am going to spend my summers in Maine and in the winters I am going to live among the good people." Unfortunately, he had the opportunity of spending only one winter in the South after his retirement. During that winter he spent one month of it with our company, and the lessons we learned will bear fruit for many years to come. He was also very fond of Mr. Hauss of the Alger-Sullivan Lumber Company and spent considerable time with them, during which time he made an experiment in their woods on the percentage of naval stores that could be produced on certain size trees by hanging one cup or hanging two cups. I haven't this record, but my recollection is that he got between 60 and 75 percent as much with one cup as with two.

There is so much that could be said about this dear man, but time will not permit. As a little of his background I am quoting from the Journal of Forestry, September 1935. "On July 31, 1935, Dr. Austin Cary, Senior Logging Engineer, retired from the Forest Service; his career in forestry has been both long and notable starting in the 90's when forestry in this country was at its beginning. He had within five

years of a half-century of forestry experience. A keen observer and sound thinker, his outstanding contribution has been forestry that is practical—the works in the woods.

"Dr. Cary secured his A.B. degree at Bowdoin in 1886-1887 and his A.M. degree in 1890, and studied biology at Johns Hopkins and Princeton in 1888 to 1891. He was an instructor in the Department of Geology and Biology at Bowdoin in 1887-1888, taught during the spring terms at the Yale Forestry School in 1904 and 1905, and was Assistant Professor of Forestry at Harvard 1905-1909. On the industrial side his experience dates back to the 90's. From 1895 to 1904 he was forester for the Berlin Mills Company, now the Brown Company, having been cited as the first American to hold such a position with a progressive corporation far-seeing and judicious enough to plan for reforestation.

"In the field of state forestry he also took a significant part. For the two years 1909 and 1910 he was Superintendent of the State Forests of New York. Previous to that, in 1893, he was in the employ of the Maine Forestry Commission. In his work with timberland owners in the South he was constantly mindful in the important field of state forestry and was ready to promote it.

"Dr. Cary's first appointment with the Forest Service was dated March 1, 1905, the position being that of expert. His continuous employment, however, did not begin until July 20, 1910. Thus he was in the Forest Service for an even quarter of a century.

"Although Dr. Cary spent a short time in the Northwest, the bulk of his work was among the large timberland owners of the South and of the Northeast. He worked intimately in the preparation of management plans for literally hundreds of private owners in these sections, many of whom today give him full credit for starting them off in the untried field of scientific forestry practices. His keen grasp of practical forestry, unfailing good sense, modesty, and determination have perhaps been at the root of his almost universal success in dealing with forest landowners. His *Manual for Northern Woodsmen* has been printed in several editions, and he has been a large contributor to technical and trade journals.

"A Fellow of the Society of American Foresters since 1924, Dr. Cary has long been an active and loyal member. His many contributions to the JOURNAL OF FORESTRY have made him well known to the members of the Society to whom his thoughtful and vigorous handling of important forestry matters has been a continual source of inspiration."

PRESENTATION OF THE AUSTIN CARY MEMORIAL TO THE SOCIETY OF AMERICAN FORESTERS

BY H. S. NEWINS
Chairman, Austin Cary Memorial Committee

UPON the recommendation of the Austin Cary Memorial Committee, of the Society of American Foresters and friends, and approval by the Council of the Society, I have the honor to submit to the President of the Society, Dr. C. F. Korstian, of Duke University, the completed work of this worth-while project.

The committee, consisting of C. H. Coulter, Ernest F. Jones, A. B. Hastings, A. E. Wackerman, J. B. Woods, and the speaker, was appointed by President H. H. Chapman of the Society while that body was assembled at Portland, Ore., in 1936.

The plan which was contributed by the Atlanta Regional Office of the Forest Service, of the U. S. Department of Agriculture, was effected by W. H. Reinsmith and includes a composite of some of the plans submitted by Director Rudolph Weaver from the senior students of the School of Architecture, of the University of Florida. The completion upon the ground of the landscape details has been supervised by C. E. Nelson, superintendent of University Grounds.

The original plan, including an area of 22 acres, has been adhered to by the committee with infinite attention to details excepting only that in February 1938, certain changes, which were recorded and approved in a revised plan, were accepted. The revised plan did not, however, alter the original scheme of simplicity but rather enhanced the idea by eliminating the proposed lodge, fire tower, and certain associated landscape details. Otherwise, the completed picture before us today is the artist's plan toward which there have been so very many endearing contributions of effort, materials, and cash donations. These contributions have been made not alone by the Society of American Foresters throughout the United States, Canada, and abroad in their tribute to the memory of the man who was an honored Fellow within the Society but most substantially by those friends of Dr. Austin Cary who recognized in this modest and unassuming personality the embodiment of

something impersonal, particularly for the South; namely, the transition from the era of exploitation of our forest resources to the new period of a useful conservation of the forests of this great country.

The completion of this memorial has been made possible only through the unstinting assistance by means of small and large donations from many individuals and groups of persons. Their contributions have been duly recorded in the Washington office of the Society, and all expenditures of cash by the committee have been officially drawn upon the treasury of the Society at Washington, where the proper audit is filed. The committee expresses the appreciation of the Society for the humblest as well as the largest contribution to this fund and we desire to acknowledge the assistance of those public officials, federal, state, county, and civic, who have labored so ardently with us; the Works Progress Administration, the Civilian Conservation Corps, the Rural Electrification Administration, and the National Youth Administration; and similar agencies which have contributed of their efforts, as well as the equipment and tool manufacturers who have helped in bringing to realization the artist's dream of the large and yet simple memorial to the memory of the forester who was so renowned and honored. The Seaboard Air Line Railway has assisted in developing the crossing into the Memorial area and in transporting the necessary lime rock base and gravel for this purpose; the Ocala mines have supplied this base material; the Florida Gravel Company has contributed the gravel with which the State Road Department has so satisfactorily surfaced the drives of this memorial tract. The lumber companies of the South have donated cash and materials; and the lumber trade journals and other publications have assisted most generously.

And now, Mr. President, it is my extreme pleasure to submit to you the work of the Austin Cary Memorial Committee.

ACCEPTANCE OF THE MEMORIAL AND TRANSFER OF ITS CUSTODY TO THE UNIVERSITY OF FLORIDA

C. F. Korstian
President, Society of American Foresters

The life and work of Austin Cary have been most fittingly eulogized by the two preceding speakers. Even at the risk of repeating some of their statements I feel a genuine urge to bespeak a few words of tribute to the memory of Austin Cary as a man and a forester. Few, if any, foresters have been so outstandingly successful in carrying the gospel of sustained-yield forest management to the forest and wood-using industries as has the man whom we honor and memorialize today. Austin Cary possessed a characteristic, rugged individualism not shared to a like extent by any of his fellow foresters. He was a keen observer, so absolutely earnest and straightforward in his methods that he was singularly successful in applying sound common sense to private lumbering and forestry operations. The results of his labors will live for many years through the indelible imprint of his personality and wisdom on American forestry. Austin Cary was elected to membership in the Society of American Foresters in 1905. In recognition of his outstanding achievements in the forestry profession he was, in 1924, elected a Fellow of the Society of American Foresters—the highest honor that the Society can confer on any of its members.

It is an honor on behalf of the Society of American Foresters and friends of Austin Cary to accept this memorial as a fitting monument of our high esteem of him who, more than any other forester, sowed the early seeds of forest conservation in private industry in New England and in the South. So may the simple lines of this memorial, made possible through the cooperative efforts of forest owners, foresters, and friends, appropriately typify the plain living and direct and effective methods so characteristic of Austin Cary.

On behalf of the Society of American Foresters and friends of Austin Cary, I want to express our sincere appreciation of the excellent work of the Committee on the Austin Cary Memorial, and especially the utiring efforts of the committee chairman, Professor Newins, in bringing this most worthy project to completion as we see it today.

It is with genuine satisfaction, President Tigert, that I turn this splendidly conceived and executed memorial over to the University of Florida for safe-keeping for the Society of American Foresters and friends of Austin Cary. May it ever be a reminder, especially to those of us so fortunate as to have known him personally, that the good work started by him must go on, and

a reminder to future generations that Austin Cary was one of forestry's most sincere and successful pioneers and that the world is richer for his having lived and labored in it.

ACCEPTANCE OF THE CUSTODY OF THE AUSTIN CARY MEMORIAL

By John J. Tigert
President, University of Florida

On behalf of the Board of Control of the University of Florida, I accept from the Society of American Foresters and friends of the late Dr. Austin Cary this significant Memorial, located at the entrance to the University Forest which was appropriately named in 1936 the Austin Cary Memorial Forest.

We have here in our midst many persons who have come from afar to join with us in paying homage to the memory of Dr. Austin Cary. We are particularly pleased to welcome his brother, Mr. George Cary, and Mrs. Cary, together with their son and the latter's wife. As the representative of Bowdoin College, in Maine, where Doctor Cary served for a number of years as a member of the faculty, we have Dr. Charles S. F. Lincoln. Mr. George Cary also served that institution as a member of the governing board. To these honorable guests; to the members of the Society of American Foresters, of the lumber associations, of the lumber trade journals; and to all of those who have contributed in any manner whatsoever of their time, effort, and money toward this worthy memorial, I bid you welcome.

Dr. Austin Cary was stricken with heart disease April 28, 1936, on our University campus while upon an errand of sponsorship for the School of Forestry. Because of his remarkable vision of the possibilities which an adequate school of forestry might offer the people of this state, I have been encouraged to further the interests of forestry education in the University of Florida.

We are especially appreciative of the Austin Cary Memorial Set of Notes, which his estate has contributed to the University and which notes are now available for study under proper supervision.

Upon the granite memorial boulder which is before me, I can read from the bronze plaque, with pine cone frieze, the following inscription:

1865—*Dr. Austin Cary*—1936

"The Society of American Foresters and friends of Dr. Austin Cary have erected this memorial in deep appreciation of his unending interest and effort toward the promotion of sound forestry practices in the United States."

The 71 slash pines, forming the background for this boulder, typify the 71 years of age which Dr. Austin Cary attained and are indicative of a new era of forest management for the South. Just beyond the memorial grove of 71 pines is the University forest of 2,083 acres. This represents the flatwoods type such as Doctor Cary loved to roam about and to study. Here we have already established many experiments which you will observe today dealing with problems not yet solved and which will only be answered for the benefit of posterity by organized study and research. This forest has remained unscathed by fire during the two and one-half years of its protection and management by the school of forestry; and yet, at this very moment, we need only to glance beyond the borders of this protected forest to note the effects of smouldering fires. This protected forest now has established small tree seedlings upon the ground cover to supply our industries and our recreation of the future.

During the year of Dr. Austin Cary's death, there were invested in the wood-using industries of the South as much as 70 millions of dollars largely because of the progress which had been made in the interpretation of the proper forest management of our southern woods.

Thus, this magnificent and yet simple monument symbolizes an idea as well as a tribute to an individual.

It is especially significant because of the rugged personality of the character for whom we are assembled to pay tribute.

Dr. Austin Cary was recognized in his technical society as an honored Fellow; and because of his labors in the field of his profession in the far West, the North, the East, and the South, he was much endeared to those practical and commercial forest workers with whom he was associated.

To you, Doctor Korstian, President of the Society of American Foresters, we voice our appreciation of the trust which the Society reposes in us for the upkeep and maintenance of the memorial; and we solemnly pledge to keep this inviolate against trespass in so far as is humanly possible.

HORNBY'S PRINCIPLES OF FIRE CONTROL PLANNING

By H. T. GISBORNE[1]

Northern Rocky Mountain Forest and Range Experiment Station

On August 27, 1937, Lloyd G. Hornby died of heart failure on the Toboggan Creek forest fire in the Clearwater National Forest. Few if any men in or out of the U. S. Forest Service have made a greater contribution to fire control planning than did he. In the following article, H. T. Gisborne outlines the principles of fire control planning developed by Mr. Hornby, emphasizing the major features which have too often been obscured by the detailed technical procedures of the component processes of fuel type classification, seen area mapping, smokechaser coverage, transportation planning, etc.

WHEN Lloyd G. Hornby was placed in charge of fire control planning research at the Northern Rocky Mountain Forest and Range Experiment Station, he brought to the task a background of training, experience, and inherent ability which was unique as it was well suited to the opportunities of this work. His training in both engineering and forestry, his fifteen years of field experience from smokechaser and ranger to supervisor of three national forests, and his exceptional ingenuity, practically assured a research that would make a major contribution to forest fire control. It is universally conceded that his *Fire Control Planning in the Northern Rocky Mountain Region* has revitalized and very nearly revolutionized fire control planning processes throughout the United States.

It was Hornby's plan, before he died on the fire line in August 1937, to summarize the principles basic to his work, but except for a three-page long-hand draft of a memorandum found in his files after his death, this summary was never written. On the basis of this memorandum, his various reports, and six years of almost daily contact and work with him, the writer here attempts to outline those principles as accurately as one person can attempt to present material for another person. The analogies used in several cases to emphasize the similarity between fire control planning and engineering practices are Hornby's own, which he employed frequently.

The eight major principles which, with one exception, are apparent in his published report can be briefly expressed as follows:

1. Held line must be built faster than the fire makes perimeter.
2. Fuel type classification is necessary to show the two basic factors: rate of spread and resistance to control.
3. Plans must be made for first-attack control before the fire commences to spot or crown except under class 6 or class 7 danger in the extreme fuel types.
4. Fuel type, occurrence of fires, and values at stake must be coordinated for most economical yet adequate fire control.
5. Lookouts, firemen, and crews have the dual responsibility of detection and smokechasing.
6. Transportation and communication planning should follow and be based upon fire control planning and other forest-use requirements for multiple use.
7. Fire control planning for the "worst first" automatically simplifies the process.
8. The conditions creating a fire problem are not static. Fire control planning is therefore a continual process of revision and refinement.

The first, and perhaps most basic, principle developed by this research was that successful fire control requires "held line to be built faster than the fire makes perimeter." This principle had been subconsciously and dimly recognized in the past, but it has been within the past few years only that the old method of estimating the job of line building on the basis of acres of fire was replaced by estimates based on *perimeter*. This first principle recognizes the superiority of the perimeter basis, and in addition considers the fact that fuel type is the major determinant of the rate of spread or rate of perimeter increase, which must be assumed for each area in planning normal control measures for it. Omitting proper consideration of fuel types in fire control plan-

[1]Acknowledgment is made to Clayton S. Crocker and Clarence B. Sutliff, who also had worked closely with Mr. Hornby, for reviewing this article and for their suggestions for improving its accuracy and scope.

ning is analogous to an engineer planning to construct a massive building without examining the rock or quicksand on which it is to rest. "Proper consideration" may vary, of course, from broad generalizations in regions of uniform fuel types to detailed measurements, surveys, and maps in regions of great variation in rate of spread of fire.

The second principle, which logically follows, is to measure and rate this basic factor, fuel type. To do this Hornby originated the dual basis, physical classification of fuel types including rate of spread and resistance to control. His methods of evaluating these are described in "Fire Control Planning in the Northern Rocky Mountain Region," and "Fuel Type Mapping in Region One."[2] He assumed "burning severity," class of fire danger, or fuel condition, that should be used in fuel type mapping to be "average bad," leaving its precise definition to be determined later by actual measurement. Here he followed the practice of an engineer who would estimate his costs of making excavations in clay on the basis of the clay being wet, and therefore more difficult to handle than if it were dry. The precise definition of "wet" is of less importance than would be the complete failure to consider this condition. The measurement rather than the approximation of each fuel type is one phase of this work requiring much additional research. Hornby was engaged in such work the day he died.

A brief statement of Hornby's conception of fuel types and their basic use was included in his final memorandum: "When a particular level of burning severity prevails over a large area, the same speed and strength of attack is not required for every kind of fuel" . . . . . "One way to station manpower over an area is to accept the judgment of some person or persons, with or without going to the trouble of comparing fuels and mapping their locations. Another way is to map the fuels, set up minimum standards of speed and strength of attack according to severity of burning conditions, and station manpower to satisfy these requirements. Under the latter procedure the same class of fuels would receive the same treatment (degree of fire control) wherever it existed and whenever the burning severity required it, other considerations being equal."

One impediment to the understanding and proper use of fuel type maps is the fact that individual fires often spread at rates different from that indicated by the map. It is obvious, however, that even the most carefully identified and mapped rate of spread, at a certain, average bad level of burning severity, will not be reached under favorable weather conditions and will be exceeded when the weather is worse than average bad. No single map could be made, and kept simple, which would show all rates of spread for all weather conditions. The major purpose of this work is not to produce a fuel type map which can be used for determining the manpower to send to individual fires, under any combination of weather conditions. The chief purpose is to determine the normal high-rate of perimeter increase which can be expected so often or so consistently that it should be planned for. This normal, high-rate varies significantly according to fuel type. This principle therefore holds that it is better engineering, better forestry, better science, to identify such a factor consciously and according to certain standards rather than subconsciously and without universal standards.

This illustrates the research quality of this work. The objective is the evolution of a *method* which can be used similarly by all men, in preference to "the judgment of some person or persons with or without going to the trouble" of identifying and evaluating all the factors. It has been consistently realized that the present evaluations of fuel type can be improved, with time and additional research, but fire control planning without fuel type classification is, to use another analogy, like estimating the cost of road or railroad construction from a topographic map alone with no knowledge of the soils, clay banks, or rock ledges through which the cuts must be made.

The third principle is that control of a fire (in Region One) by the first attacking forces should be planned for "before the fire begins to spot or crown." Other criteria such as "control before 10 a. m. of the next burning period," and the "percentage of area burned," by timber types as recommended by the regional foresters, Washington conference of 1930, have been used, but for the reduction and gradual elimination of those large fires

[2]Hornby, L. G. Fuel type mapping in Region One. Jour. Forestry 33:67-72. 1935.

which are chiefly responsible for overburn, a more basically natural criterion is needed. Hornby insisted that "after the crown fire stage is reached, no assurance of control at any particular size can be given," and under certain conditions this stage may be reached before 10 a. m. of the next burning period. He also pointed out that the analysis of the records of 12,056 fires in Region One shows that over a period of years silviculturally adequate protection, the basis of the Washington conference standards, can be provided without 99.99 percent control of all fires in the first or even the second work period.

The likelihood of spotting or crowning varies, of course, both with fuel type and with burning severity. The present principles, however, do not include plans to meet the worst possible conditions of either fuel type or class of fire danger in the first attack any more than an engineer builds to withstand the worst possible earthquake or the worst possible flood. Engineers know that the damage in such cases is often less than the cost of complete protection. This third principle of "control before crowning" therefore excludes those rare fires originating in extreme fuel types on class 6 or 7 days, when fuel moistures are under 5 percent, relative humidity under 15 percent, and winds 19 m.p.h. or more. The damages from such explosive fires can most economically be minimized by large crew suppression action, the same as for other fires which for other reasons escape control by a reasonably economical first attack.

The fourth principle is that fuel types, occurrence of fires, and values at stake must be coordinated by the processes of planning if the resultant permanent facilities (buildings, roads, and telephone lines) and the temporary manpower (contact men, lookouts, smokechasers, and small crews), are to be held to an economical minimum, yet adequate protection is to be provided during seasons of critical danger. The use of this principle is not as apparent in Hornby's major reports as are the other principles. This is because it has not been expedient to date to attempt to place dollar values on each of the diversified uses or purposes of forest areas including stream flow regulation, soil conservation, wildlife production, recreation, live-stock, and timber products. Fire control planners cannot escape, however, from the need of attempting to apply this fourth principle, including values as well as fuel types and the occurrence rate.

The fact that valid inferences cannot be drawn unless the measurements or ratings of all the basic factors are integrated led Hornby to his search for a "total danger rating" which would integrate fuel types, occurrence, and values. He was never completely satisfied with the formula that he originated. By this formula there is obtained from the fuel type maps an estimate of the acres per hour that will probably burn during the first few hours after origin on an average bad day. This, multiplied by the damage, in dollars, that would be done, is called "damage per hour." Then damage per hour plus expense per hour (based on the fuel type classification of resistance to control) gave total probable "cost per hour" for any unit of area. And cost per hour multiplied by the occurrence index for that area gives a figure approximating "total danger." Such numerical ratings for different areas can be compared and the relative needs for fire control facilities and manpower thereby determined, with less than previous dependence upon the personal judgment, knowledge, lack of knowledge, or bias of the individual.

This attempt to obtain numerical ratings is additional evidence of the scientific quality of this research. It is emphasized by Lord Kelvin's statement, "that when you can measure what you are speaking about, and express it in numbers, you know something about it. But when you cannot express it in numbers your knowledge is of a meager and unsatisfactory kind. It may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the stage of a science."

The impossibility of immediately evaluating all of the factors of "total danger" with consistent dependability is obvious. But here again, as in fuel type mapping, it is evident that carefully prepared estimates can now be made, with a sufficiently low error to give a better basis for fire control planning, more "independent of the idiosyncrasies of the individual."

The fifth principle which is contrary to practices in some sections of the country is the "dual responsibility" of lookouts, firemen, and crews. This had been applied with gradually increasing intensity in Region One begin-

ning about 1920. As national inspector of fire control, Major E. W. Kelley gave marked impetus to the practice in 1927 to 1929. By this principle lookout men are not only to chase smoke when that can be done without impairing the detection coverage, but lookout station locations are to be selected, other things being equal, so that these men can serve this dual purpose. It would appear to be decidedly uneconomical to build a lookout system capable of first discovering 99.99 percent of all fires when firemen, trail crews, and several other units of the fire control organization can be depended upon for considerable detection coverage.

Closely related to this fifth principle of "dual responsibility" is the sixth, or "multiple use of roads." Although not generally recognized at the time Hornby was developing his principles, it is now standard practice to plan for the lower cost, to each line of work, and the greater efficiency of a transportation system designed by correlating the requirements for (1) fire control, (2) utilization or removal of forest products, (3) recreation and (4) general administration. By this principle, transportation planning is a distinctly accessory process which should follow and be based upon the previous determination of manpower placement adequate for fuel types as well as for other forest requirements. Communication planning similarly becomes a subsequent process; it is even dependent upon, or at least affected by, the results of transportation planning. Transportation or communication planning without complete consideration of fuel types and their manpower requirements, or without correlating utilization, recreation, grazing, and other needs is analogous to dam construction without streamflow measurements. Such dams have been built—and rebuilt, after the high-water that should have been foreseen.

The seventh of these principles for fire control planning is to plan first for the worst, or for the "worst first." By "worst" is meant the most dangerous fuel types. The plans for 10 national forests comprising 17 million acres of land in Region One have repeatedly demonstrated that if provisions are made first for the worst fuel types a large proportion of the easier types is automatically given satisfactory, or even superlative detection, smokechaser, and crew coverage. By this principle large crew coverage (provided merely by roads from outside sources of labor) is planned for all areas of fuels in which fire could be expected to escape any reasonably economical first attack, as mentioned in discussing the third principle. Naturally, these most difficult fires are most likely and should be expected most frequently in the worst fuel types. The action demanded, under such conditions, is suppression by large crews, and roads must be available reasonably near such areas of worst fuels to expedite arrival of these large suppression crews. If these roads are planned first, later planning of roads for use by small crews, smokechasers, and firemen-lookouts, will automatically benefit. By the reverse process roads are first planned for the lookouts, smokechasers, and patrolmen, and are often found to be unsatisfactory for expediting the arrival of large crews at the areas of worst fuels where the catastrophic fires are most likely to originate. As the reduction of the size of large fires is the present major requisite to satisfactory fire control, logical planning must be for the "worst first."

The eighth, and final, principle applied throughout all phases of fire control planning in Region One is that none of the basic factors of the fire problem—fuel type, occurrence, or values at stake—is constant or static. Each of these is known to change, perhaps slowly, with time. The rating of the relative weight of each factor therefore undoubtedly will change, slowly but steadily with increased knowledge, and perhaps radically for short periods according to the dominance of some individual's philosophy. Preliminary plans therefore should deal with averages, with indicative trends, with combinations of factors, always endeavoring to prevent single and exceptional cases from resulting in over-building or completely neglecting any essential phase of the fire control organization. Likewise, this principle should temper all finality of conclusion and should predicate continual revision and refinement of the plans.

Hornby's contention, supported by ample evidence in Region One, that a strong and apparently costly first attack is usually the most economical in the most dangerous fuel types, can hardly be called a principle. It is, however, a generality supporting his worst first principle, and one which is basic to the proper

financing of adequate fire control in this region.

The personnel factor was recognized by Hornby as vital. He stressed the requirement of both adequate numbers of men and adequate training. His last memorandum states: "Errors (on the fire line) are so numerous that their elimination constitutes an outstanding problem," and, "Rates of fire suppression work, per man per hour, are so slow that unwieldy numbers of men are required even on fires of moderate size." These phases of fire control planning, and the prevention of fires, were recognized by Hornby as calling for such distinctly different action as to be outside the scope of his particular research.

The little pessimism that Hornby felt concerning the possible progress of fire control planning arose from the indeterminacy of the personnel factor. He had had so much personal experience in the loss of trained and competent short-term members of his national forest fire control forces, and had seen the deleterious effects of the short-term limitation on so many other forests, that he was occasionally pessimistic concerning the successful application of his or anyone else's fire control plans. He knew that the best of plans, based on specific identification of all significant factors, each well evaluated, and all consistently integrated, could not function most efficiently unless applied by a competent personnel. He knew that any lack of policy or financial limitation, which interfered with the retention, year after year, of a trained and competent personnel could prevent the full improvement of fire control efficiency that might be expectable from planning methods that he or anyone else might devise. He confined his work, however, to developing *methods* and a planning procedure which would provide any personnel with facilities impersonally suited to local conditions of fuel type, occurrence of fires, and values at stake.

A DESIGN FOR EXPERIMENTS IN THINNING FOREST STANDS

By J. G. OSBORNE

Southern Forest Experiment Station[1]

Thinning experiments have taken up a consistently large share of forest-research programs, and can be expected to continue to do so. This paper presents an experimental design which is intended to aid in increasing the amount of information obtained from such experiments.

MANY of the early experiments in forestry were made to determine the effects of various methods of thinning on tree growth and on the yield per acre in various forest products. Since these studies have continued to occupy a prominent position in forest-research programs, and since, as stated by Yates (*3*), it is profitable to expend considerable work in developing a technique in a field in which much experimental work is likely to be undertaken, it has been considered worth while to devote at least some research to improving the technique of thinning experiments.

Objectives of a Satisfactory Technique

The type of stand to be thinned, the method of thinning employed, and the kind of final stand sought vary widely, but certain principles of experimentation are common to all thinning research. Efforts towards developing an adequate experimental design, therefore, must be made in accord with at least four basic requirements, which briefly stated are:

(1) That adequate provision be made to assure the reliability of the results obtained;

(2) That the experiment be efficient, which means that early and accurate information be obtained, and that the number of plots and total area necessary to provide a given body of information be at a minimum;

(3) That the experiment should permit the induction of general principles of response, from which the probable results of thinning under other conditions may be deduced;

(4) That, in order to obtain assured reliability of the results, the limitations as to original

[1]The author gratefully acknowledges the assistance and helpful suggestions given by R. A. Chapman, H. Bull, and A. L. MacKinney of the Southern Forest Experiment Station, and by F. X. Schumacher formerly of the U. S. Forest Service, Washington, D. C.

stand characteristics must not be so rigid as to make location of suitable experimental areas prohibitively laborious.

Previous Methods of Experimentation

In earlier experimental work in thinning, serious consideration was given only to the first of these four objectives, and even this received adequate consideration only in recent years. In the earlier experiments, the comparability of stands to be thinned with stands to be kept as controls was judged almost entirely on appearance of the stands, on basal areas, or on number of trees per acre. In 1929, a rigidly defined objective method of insuring comparability was introduced by Barrett and Righter (*1*), who proposed a statistical test of the agreement of the averages and of the dispersions of the diameter distributions compared. According to their method, stands were adjudged comparable when the differences between the average diameters and the coefficients of variation of the diameter distributions did not exceed twice their standard errors. Arbitrary requirements were added later to these tests, in order to insure constancy of soil series, similarity of numbers of trees per acre, and site indexes.

It seemed reasonable to assume that if stands were closely enough alike to satisfy these rigid requirements, similar residual stands surely would be selected, and any growth differences found could safely be attributed to treatment. The method satisfied the first of the listed requirements for an adequate experimental design for thinning but did not take into account the other three requirements. The test of the significance of differences following treatment, which consisted of a comparison of the differences in the new average diameters with the errors of the differences at successive remeasurements, was valid but not sufficiently sensitive. Since the range in the diameters of the residual trees was usually wide enough to create a large error of the average, and therefore a large error of the difference between averages, it was not sensitive enough to allow the detection of real treatment effects in the earlier remeasurements. Furthermore, as is true of most systems of experimentation involving mechanically paired plots, a great number of plots was necessary before the information obtained could be generalized. Usually the experimenter could give assured results only for the particular, isolated condition used in his test, and was limited to the statement that a stand of a given description, following a specific treatment, showed a specified acceleration in average-diameter growth. Most serious, however, was the extreme difficulty encountered in locating stands that satisfied the exacting limitations imposed.

Description of the Proposed Method of Experimentation

The almost impossible difficulty of locating enough suitable experimental areas, and the limited interpretations possible from results based on entire stands, have made the use of the individual tree as the unit of study seem desirable. Turning from the stand to the tree does not appear to be entirely illogical since, in the ultimate analysis, thinning in practice is always based on the choice of individual trees, with, of course, due consideration to their surroundings. As the volume per acre can be computed if one knows the volume of specified trees and the number of such trees per acre, so can one compute the response to thinning in yield per acre, of whatever kind desired, if one knows what a specified tree will do under a given set of conditions and the number of such trees per acre.

The innovations of the method proposed consist of: (1) using the regression method to adjust for original tree differences; (2) establishing plots according to a carefully planned field arrangement, which permits evaluating and adjusting for site-quality trends by means of analysis of variance; and (3) computing equations that allocate the response following release to the tree factors through which it is obtained.

Recent measurements have confirmed what has long been concluded from observations: that trees of the same species, age, size, and crown measurements are alike in their capacity to grow. By means of a mathematically defined relationship between growth and tree characteristics, the investigator is able to make adjustments for differences in original tree measurements so that he can, in effect, compare the growths of trees of identical growth capacity under the different treatments. By means of analysis of variance with a carefully planned field arrangement, place-site correlations can be evaluated and their influence removed, thus rendering strict pairing by sites unnecessary. By means of these expedients, comparability is

achieved, and as reliable conclusions are assured as by mechanical pairing. In addition, irrelevant variation is greatly reduced, so that small, real treatment effects are detected readily. Apart from the tests of significance, the regression method enables an examination of the effect of the various tree characteristics studied on the response to the different degrees of thinning. Such information should serve as a useful guide in future thinning. Finally, knowledge of the growth capacity of trees of given characteristics will permit a comparison between stand tables obtained following thinning and those theoretically obtained with no thinning. and thus provide a monetary evaluation of the treatment.

Specifically, plots are laid out in the stand, and treatments are assigned at random, according to the Latin square, randomized blocks, or some other field arrangement designed to eliminate place-site correlations and to insure a valid estimate of experimental error. To obtain a mathematically defined relationship between growth, however expressed, and tree characteristics, an equation is fitted by the method of least squares. Growth may be expressed as increment in diameter at breast height, cubic volume, height, or in any other terms desired. The equation, fitted to relationships among trees on the untreated plots, permits estimating growth for a tree with any set of measurements within the range of the data. To form this equation of growth on the check plots, all trees should be used in older and less dense stands, since all trees may enter into utilization computations. With young stands, for example, stands under 15 years old, with more than 2,000 trees per acre, it is sufficient to include only enough of the larger and more thrifty trees to insure that the number of best residual trees corresponding to the lightest thinning is among them. If the relationship of growth to the tree characteristics studied is found, on testing, to be curvilinear, either of two courses is open. The investigator may (a) arrive at a set of curves showing the relationships, through a series of graphic approximations beginning with the mathematically determined linear relationships, or he may (b) choose a curve type capable of representing the relationships for which the use of polynomials is recommended.

The method of determining the equations of response for each of the thinnings used will depend on whether the equation of growth on the check plots is linear or curvilinear. If linear, it is necessary simply to compute similar linear equations for the group of plots in each treatment, then to subtract check plot equations from those for treatment plots. If curvilinear, growth is estimated for each tree with a given treatment, and the errors of estimate are correlated with the tree characteristics.

To determine whether thinning has produced a significant effect on growth, an analysis of variance is made of the average deviations of the actual growth for each of the plots from that estimated.

The method proposed is subject to the limitation that only one age and one site are sampled on any single group of subplots; to solve the thinning problem for a range of ages and sites, a number of sets of such subplots will be required. The method does, however, make much more efficient use of a given sample area, and it will greatly reduce the total number and aggregate area of sample plots needed to furnish comprehensive answers to the problems of thinning.

Example of Application

The mechanics and details of the proposed design and analysis can be described more adequately by an example. For this purpose, 2-year remeasurements of a set of thinning plots in slash pine will be analyzed according to the method suggested. In February 1933 the Southern Forest Experiment Station established a block of twenty 1/10-acre thinning plots in 12-year-old slash pine in south Georgia. The stand on these plots varied in density from 1,400 to more than 8,000 trees per acre. Figure 1 shows the field arrangement used, together with contour lines at 0.1-foot interval. The contour lines are shown because soil, and therefore probably site, differences in this region are strongly correlated with slight local differences in elevation. A swampy area closely approaches the lower side of these plots and accentuates the effect of elevation; differences in elevation as small as 1 foot may result in one area being frequently wet and the other only rarely so. It is obviously important that location be recognized and, as far as possible, be taken into account in a study of treatment effects.

It will be noted that in the main body of

plots, A-1 to D-4, the treatments are arranged according to a Latin square, with each treatment occurring in each row and column. Plot D-3 occurred in an entirely different universe[2] and was omitted, G-1 being installed as a substitute. The block E-1 to F-2 was added as a fifth replication of the treatments in a continuation of the same stand.

The three treatments consisted in thinning to leave residual stands composed of the best 200, 300, and 400 trees per acre, respectively, selecting each tree so that it had approximately the space that it would have had under absolutely uniform spacing, e. g., for the 400-per-acre treatment, each tree chosen had an average spacing of 10.4 feet on three sides. All residual trees on the thinned plots were numbered for identification when remeasured. On the check plots, a sufficiently large number of trees was selected to insure including the best 400 trees per acre, and each tree was numbered—as on the thinned plots—the number per acre marked varying from 650 to 810. All other trees on the check plots were tallied by 1-inch diameter-classes for a study of mortality. Diameters, heights, and crown lengths were measured, and

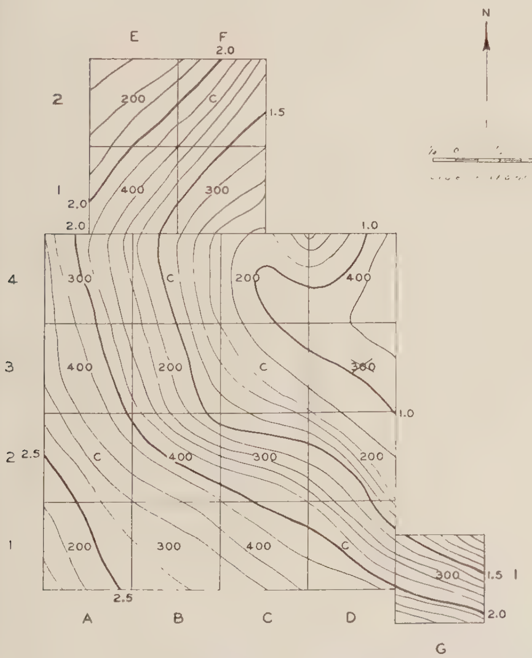


Fig. 1.—Field arrangement and topographic map of plots.

[2]The stand on this area consisted of several large maples, a few older slash pines, and many slash pine seedlings 2-6 feet high.

crown widths were estimated for all residual and marked check-plot trees. In February 1935, all tree diameters were remeasured, and the 2-year growths were computed by subtracting the 1933 diameter measurements from those of 1935.

Analysis of Data

The work of using individual tree measurements may at first seem prohibitive, but it is greatly reduced in the analysis of the second and succeeding remeasurements. The majority of the squares and cross-products will be identical for each new analysis, since they will be based on the tree measurements of the first year. In the new correlation analyses, therefore, only the squares and cross-products involving the dependent variable, growth, will need to be re-computed.

To the check-plot data described was fitted an equation of the type

$$X_1 = a + b_1X_2 + b_2X_3 + b_3X_4 + b_4X_5$$

where

X_1 is the diameter growth, in inches; X_2 is the 1933 diameter, in inches; X_3 is the 1933 height, in feet; X_4 is the 1933 crown width, in feet; and X_5 is the 1933 crown length, in feet.

The equation obtained was

$$X_1 = .091314X_2 - .027966X_3 + .050112X_4 + .025116X_5 + .405341$$

When the data were plotted, no marked curvilinearity was found in the relationship between growth and any of the tree characteristics. Indications are, however, that a curvilinear relationship between growth and diameter may develop later.

From the equation one could estimate the growth, under unthinned conditions, of a tree of any dimensions within the range of the data, assuming that it grew on the average site represented and with the average spacing per tree for the check plots. When the growth of trees on both thinned and unthinned stands was estimated, any deviation of the actual growth of a tree from its estimated growth could then be attributed to differences in site, treatment (or spacing), and to random error. From the equation, the growth of each tree was estimated, and the deviation of the actual from the estimated growth computed. The average deviation was then computed for each plot. The analysis of the significance of differences then dealt entirely with these deviations or errors of estimate.

Normally the field arrangement in a set of thinning plots will follow the regular randomized-block or Latin-square design. In the present example, in which a slight departure is made in order to use the extra block of plots E-1 to F-2, the analysis makes use of the Latin-square arrangement of the main block of plots, and then considers this block, with the remaining block of four plots, as two groups, making two unequal-sized randomized blocks.

Table 1 shows the data in accordance with the field arrangement.

The analysis of variance for the Latin-square block is shown in Table 2. This is followed by Tables 3 and 4 showing the contributions of the additional block of plots.

For 3 and 6 degrees of freedom, according to Snedecor (*2*),

$$P = .05 \text{ when } F = 4.76$$
$$P = .01 \text{ when } F = 9.78$$

Thus, with only the 16 plots of the Latin square, treatment is a highly significant source of variation.

The additional 4 plots raise the available number of independent comparisons from 15 to 19, the 4 additional degrees of freedom contributing 1 for the comparison of groups and 3 for interaction of treatments with groups. Table 3 supplies the data for these comparisons.

An analysis of variance of these growth deviations is shown in Table 4.

The difference between the treatment sum of squares .297296 for the entire 20 plots and .265540 for the 16 Latin-square plots or .031756 when added to that for the interaction of treatments and groups (.008211) gives the sum of squares of the deviations of plots E-1 to F-2 from their mean, or .039967.

Table 5 shows the completed analysis of variance, combining the Latin square and the additional block of plots.

For 3 and 9 degrees of freedom,

$$P = .05 \text{ when } F = 3.86$$
$$P = .01 \text{ when } F = 6.99$$

The addition of 4 plots is seen to increase the F value for treatment from 13.00 to 18.18, while the additional degrees of freedom reduce the value necessary to establish significance at the 1-percent point from 9.78 to 6.99. The standard deviation of a single plot is reduced from $\sqrt{.006808}$ or .082510 to $\sqrt{.005451}$ or .073831. Place did not contribute more than its expected share to the total variation.

TABLE 1.—AVERAGE DEVIATIONS OF ACTUAL FROM ESTIMATED DIAMETER GROWTH, GROUPED ACCORDING TO FIELD ARRANGEMENT[1]

	Group 1 (Latin square)				
	1	2	3	4	Totals
A	(2) +.157	(c) +.074	(4) +.229	(3) +.390	+.850
B	(3) +.225	(4) +.242	(2) +.410	(c) +.046	+.923
C	(4) +.245	(3) +.323	(c) +.004	(2) +.342	+.914
D	(c) —.072	(2) +.471	(3) G-1 +.298	(4) +.185	+.882
Totals	+.555	+1.110	+.941	+.963	+3.569

	Group 2	
	1	2
E	(4) +.178	(2) +.175
F	(3) +.228	(c) —.032
Total		.549

Treatment	Total	Average
200	+1.555	+.311
300	+1.464	+.293
400	+1.079	+.216
Check	+0.020	+.004

[1]Treatments are shown in the upper left-hand corner of each cell. Treatments 200, 300, 400, and check are represented by (2), (3), (4), and (c), respectively.

The standard error of a treatment mean is $\frac{.073831}{\sqrt{5}}=.033018$ and the standard error of the difference between two treatment means is 1.414 (.033018) or .046687. Since for 9 degrees of freedom the 5-percent and 1-percent levels of t are 2.262 and 3.250, respectively, according to Snedecor (*2*), any difference between treatment means greater than 2.262 (.046687)=.1056 is adjudged significant at the 5-percent level, and any difference greater than 3.250 (.046687)=.1517 is adjudged significant at the 1-percent level.

Differences between treatment means were found to be

$M_{200}-M_{300}=.018$ $M_{300}-M_{400}=.077$
$M_{200}-M_{400}=.095$ $M_{300}-M_{c}=.289$
$M_{200}-M_{c}=.307$ $M_{400}-M_{c}=.212$

All treatment and check-plot differences are significant at the 1-percent level but no treatments differed significantly from the others.

Effect of Tree Characteristics on Response to Thinning

Having determined the significance of the effects of treatment, we may now investigate the part each tree characteristic plays in the response to thinning. This information should be of considerable value in determining the optimum residual density for a particular stand and in estimating the response to treatment.

To determine the effect of original tree characteristics on response to thinning, separate equations involving the same variables as in the equation for the check plots were computed for the trees in each treatment. The equation for the check plots was subtracted from the equations for each of the treatments. The equations of the differences between thinned and check plots are evidently the equations of response to thinning. These treatment and difference equations were as follows where X_1, X_2, ... X_5 have the same meaning as before:

In considering the effect of variation in these tree measurements on the response to thinning to different densities, it must be pointed out that the treated stands were young and still vigorous, and that even with the lightest thinning the residual trees apparently were not crowded.

The difference equations indicate that, after allowing for the effect of variation in height, crown width, and length, trees of smaller diameter (see coefficients of X_2) showed a greater response to thinning to the intermediate residual densities (300 and 400 trees per acre) than did the larger trees. Only when the density was more greatly reduced, were the larger trees able to show as great a response as the smaller. The effect of original height differences (see co-

Table 2.—Analysis of Variance of the Latin Square

Variance due to	Degrees of freedom	Sums of squares	Mean squares	F[1]
Rows	3	.000827	.000276	
Columns	3	.042134	.014045	
Treatments	3	.265540	.088513	13.001
Error	6	.040848	.006808	
Total	15	.349349		

[1]F is the ratio of the larger to the smaller mean square.

Table 3.—Deviations of Actual from Estimated Average Diameter Growth, by Groups of Plots and Treatments

	Groups		
Treatments	Group 1 Latin square (16 plots)	Group 2 E-1 to F-2 (4 plots)	Totals
200	+1.380	+0.175	+1.555
300	+1.236	+0.228	+1.464
400	+0.901	+0.178	+1.079
Check	+0.052	—0.032	+0.020
Totals	+3.569	+0.549	+4.118

$$
\begin{aligned}
X_1\ 200 &= .088805X_2-.004213X_3+.020487X_4-.001401X_5+.588805\\
X_1\ \text{Check} &= .091314X_2-.027966X_3+.050112X_4+.025116X_5+.405341\\
\hline
X_1\ 200-X_1\text{Check} &= -.002509X_2+.023753X_3-.029625X_4-.026517X_5+.183464\\
X_1\ 300 &= .037016X_2-.015133X_3+.033087X_4+.027169X_5+.626687\\
X_1\ \text{Check} &= .091314X_2-.027966X_3+.050112X_4+.025116X_5+.405341\\
\hline
X_1 300-X_1\text{Check} &= -.054298X_2+.012833X_3-.017025X_4+.002053X_5+.221346\\
X_1\ 400 &= .068206X_2-.005065X_3+.014723X_4+.022135X_5+.318643\\
X_1\ \text{Check} &= .091314X_2-.027966X_3+.050112X_4+.025116X_5+.405341\\
\hline
X_1 400-X_1\text{Check} &= -.023108X_2+.022901X_3-.035389X_4-.002981X_5-.086698
\end{aligned}
$$

efficients of X_3) was practically independent of the severity of the treatment. For all three treatments the taller trees, other factors being adjusted for, showed greater response to thinning than the shorter trees. Likewise, for all three treatments, trees with originally narrow crowns (see coefficients of X_4) showed greater response to thinning. Differences in original crown length (see coefficients of X_5) apparently had little effect on the response to thinning to the intermediate densities, but following the heavier thinning (to 200 trees per acre) the short-crowned trees showed a definitely greater response than those with longer crowns.

The growth equation for the check-plot trees indicates the influence of variation of the individual tree characteristics on diameter growth in the untreated stand. Evidently the trees that grow best are those of larger diameter and with long, wide crowns. This is in accord with the recent findings (at the Southern Forest Experiment Station and elsewhere) that diameter growth is related directly and closely to the ratios of crown length and crown width to total height. The difference equations show the types of tree which are likely to give the greatest response to a given intensity of thinning.

These analyses add further information as to the advisable degree of thinning and as to the number of trees of good growth capacity available at the age of this stand when thinned. They also enable one to make a comparison of two methods of evaluating the effect of thinning. Essentially, the difference in the two methods is that in one the trees on the check plot (to be used in later comparisons with the same numbers of trees on the thinned plots) are selected at the time of thinning; in the other, they are selected at the time the comparison is made. Since the two methods serve different purposes, the one chosen will depend upon the point of view. It may be argued that the purpose of the experiment is to compare the growth of the residual trees on a thinned plot with that of the same number of trees selected as the best trees on the check plot, in which case the trees for comparison will be selected at the time of thinning. A practical consideration that must be faced, however, is that growth on the thinned plot is limited to the residual trees, whereas on the check plot the best growth may be obtained on any group of trees. The true evaluation, therefore, of the thinning lies in a comparison of the growth on the thinned plot with the best growth on the check plot. The method in which the growth of trees on the thinned plot is compared with that of trees on the check plot as nearly identical as possible is a variation of the first method.

A comparison of the results using the first two methods is shown in Tables 6 and 7. In Table 6 a comparison is made of the actual and predicted growth of the specified number of trees having the highest predicted growth, and in Table 7 of the specified number of trees having the highest actual growth. For example, line 2, column 1, in the body of Table 6, shows that the 200 trees having the best predicted growth out of the 300 residual trees had an

Table 4.—Analysis of Variance of Growth Deviations by Treatments and Groups of Plots

Variance due to	Degrees of freedom	Sums of squares
Treatments	3	.297296
Groups	1	.023564
Interaction (treatments and groups)	3	.008211
Total	7	.329071

Table 5.—Analysis of Variance of Growth Deviations for the Latin Square and Plots E-1 to F-2

Variance due to	Degrees of freedom		Sums of squares		Mean squares	F^1
Place	–	7	—	.066525	.009504	
Rows	3	–	.000827	—	—	—
Columns	3	–	.042134	—	—	—
Groups	1	–	.023564	—	—	—
Treatment	–	3	—	.297296	.099099	18.18
Remainder	–	9	—	.049059	.005451	—
Latin-square error	6	–	.040848	—	—	—
Tr. x gr.	3	–	.008211	—	—	—
Total		19		.412880		

[1]F is defined in footnote of Table 2.

average predicted growth of 0.676 inch and an actual growth of 0.939 inch. In the same cell of Table 7 it is seen that the 200 out of 300 trees with the highest actual growth had a predicted growth of 0.650 inch and an actual growth of 0.999 inch. In Table 6 the actual and predicted growth of the specified number check plot having the best predicted growth are identical (line 4, column 1), whereas in Table 7 the 200 trees on the check plot having the highest actual growth had an average predicted growth of 0.664 and an actual growth of 0.783. By way of interpretation, Table 6 shows a growth excess for the stand thinned to 200 trees of 0.948—0.645 or 0.303 inch over the check plot. Table 7, on the other hand, shows that the acceleration of the 200 trees on the plot thinned to 200 trees per acre over the 200 trees having the best growth on the check plot is only 0.303—0.119 (i. e., 0.783—0.664)—0.184. Similarly, on the plots thinned to 300 trees per acre, the effectiveness of thinning is reduced from .279 (Table 6) to .186 (Table 7) by the change in the method of comparison. It is evident (a) that the first method of comparison will consistently favor the thinned plots over the check plots, and (b) it will favor the more heavily thinned plots over the more lightly thinned ones.

A study of the values of predicted growth in Table 6 indicates that at this age, site, and original density little sacrifice is necessary in the quality of tree selected whether 200, 300, or 400 trees per acre are chosen. The 400 trees selected are, on the average, a little poorer in growth capacity than the 300, which in turn are a little poorer than the 200; an attempt to select 650 to 800 trees must include a number of poorer trees whose average growth capacity is somewhat reduced.

Table 7 shows that at this age of stand, if a later residual stand of 200 or 300 trees per acre is wanted, little is lost in growth of the residual trees even if the original thinning is light enough to leave 400 trees per acre. That is, the best 200 trees per acre, with approximately the same growth capacities, grew as well whether 200, 300, or 400 trees per acre were left. When the residual stand was 400 trees per acre, the best 200 trees with a growth capacity of .670 inch actually grew .956 inch, whereas a residual stand of 200 trees per acre with a growth capacity of .645 inch actually grew .948 inch. This comparison is not particularly valuable in the present case, when the period between thinning and remeasurement is only 2 years, but is cited as an example of the use of tables such as Table 7 in determining the optimum schedule of thinning.

Evaluation of the Thinning

Having the original diameter distribution of the residual trees on each of the thinned plots, as well as the height and crown measurements, the equation connecting growth to these tree measurements for the untreated stand will enable the growth of each tree to be estimated. Stand tables of the residual trees can thus be built up, showing the stand as it would have been if it had not been thinned, and as it actually was after thinning. A comparison of the values of these stands can then be made, and consequently of the cost and value of the thin-

Table 6.—Predicted and Actual Diameter Growths of the Best Trees Selected on the Basis of Best Predicted Growth

Actual residual density	Number of trees per acre on which growth is measured: 200	300	400	650-810 tagged trees—check
Trees per acre	*Average diameter growth (inches)*			
200 Predicted	.645	------	------	------
Actual	.948	------	------	------
300 Predicted	.676	.609	------	------
Actual	.939	.895	------	------
400 Predicted	.705	.650	.595	------
Actual	.894	.853	.803	------
Check predicted	.701	.666	.636	.554
Actual	.701	.673	.632	.554

Table 7.—Predicted and Actual Diameter Growths for Best Trees Selected on the Basis of Best Actual Growth

Actual residual density	Number of trees per acre on which growth is measured: 200	300	400	650-810 tagged trees—check
Trees per acre	*Average diameter growth (inches)*			
200 Predicted	.645	------	------	------
Actual	.948	------	------	------
300 Predicted	.650	.609		
Actual	.999	.895	------	------
400 Predicted	.670	.631	.595	------
Actual	.956	.888	.803	------
Check predicted	.664	.632	.610	.554
Actual	.783	.732	.690	.554

ning. Similar comparisons could be made if height, cubic volume, or some other measure of growth were studied. Thus, while this method deals almost entirely with the reactions of individual trees, stand reactions in terms of value and products are readily obtained.

Summary

A design for experiments in thinning forest stands is described. This design partly fulfills four essential requirements of experimental thinning, as follows:

1. Adequate provision is taken to assure reliability of the results by making adjustments for original differences in tree characteristics and by the measurement and removal of place-site correlations through carefully planned field arrangements and analysis of variance.

2. The efficiency is high inasmuch as early information is obtained, the necessary experimental area is reduced, and the number of plots necessary to round out a given body of information is lowered. This is attained by intensive measurements and evaluation of the effects of included variation, thus permitting the reducing of experimental error.

3. The information yielded permits of generalization and deduction. From regression equations expressing growth in terms of tree characteristics, the effect of variation in each characteristic is determined. Equations of response to thinning, as influenced by each of the tree characteristics enables one to develop principles of thinning and to determine the probable value of thinning in other stands.

4. The method is flexible enough to insure reliability of the conclusions, without placing such exacting limitations on original-stand characteristics as to make the location of suitable experimental areas prohibitively difficult.

An illustrative example is presented, with interpretations that demonstrate some of the advantages of this method of experimentation.

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AN average survival of more than 61 percent was reported for all tree species planted in farm shelterbelts and field windbreaks of the prairie plains during 1938 by the Prairie States Forestry Project. Survival of the nine species most commonly planted was 72 percent. The count was made on farms in the Dakotas, Nebraska, Kansas, Oklahoma, and the Texas panhandle.

Grasshoppers caused the greatest loss of young trees in 1938. Rabbits and mice also were responsible for some losses of the young seedlings. Drouth has not been a serious cause of tree loss at any time with the new shelterbelt plantings.

The high survival was maintained in 1938 although at least three times as many miles of shelterbelts were planted as in any previous year—4,264 miles in 1938 as compard to 1,329 miles in 1937, 1,152 miles in 1936, and 125 miles in 1935, the first year for the project.

THE RELEASE OF SEEDS FROM JACK PINE CONES

By R. K. LeBARRON and F. H. EYRE
Lake States Forest Experiment Station[1]

Jack pine fails to function satisfactorily as a seed tree in the absence of fire. A study[2] was therefore made to determine the amount and time of seed fall from cones attached to lopped and scattered branches, felled trees, and from girdled trees.

THE problem of regenerating jack pine (*Pinus banksiana*) differs from that of most northern conifers because the cones fail to release their seeds when they mature. Instead, the majority of the seeds are retained for many years in the persistent cones and normally, unless a forest fire sweeps through the stand, do not escape in large numbers.

Much seed, however, is contained in cones left in slash after a logging operation. By lopping and scattering this cone-bearing slash and permitting it to lie exposed to the heat of the sun, an abundant supply of seed can be obtained.[3] Under these circumstances the cones open readily and large quantities of seed are disseminated.

But leaving the inflammable slash seems to some foresters to be taking too much chance with fires. Some less hazardous means of causing seed dissemination would appeal to those responsible for fire protection. Since fire-killed jack pine trees readily release their seed, the question arises: Why would not trees killed by some other method be just as effective? An experiment was therefore laid out to determine the effect of girdling seed trees as compared to lopping and scattering slash on the time and quantity of seed dispersal.

Procedure

In this study, a comparison was made of the amount and time of seed fall from jack pine cones attached to (1) lopped and scattered branches (slash), (2) felled trees, and (3) girdled trees.

On May 30, 1935, two 65-year-old jack pine trees were girdled, two similar trees were felled, and branches were cut from three additional trees on the Superior National Forest, Minn. There was no shade except that cast by the branches and trees involved in the experiment. Small cages, made of common window screen (Fig. 1), were placed around several cone-bearing twigs on the standing as well as the felled trees and on the severed branches. Twenty-five of these cages, enclosing 230 cones, were widely distributed through the tops and slash so as to obtain a representative sample of cones from different portions of the trees and cones of different ages and color. The cones on the lopped and scattered branches were situated from one inch to one foot above the ground surface, those on the felled trees from one to five feet above ground, and those on the girdled trees from 20 to 40 feet.

The seeds that fell from the cones were removed from the cages and counted at intervals of 3 to 15 days from May 1935 to November 1937, except during the winter period from November to May.

Results

During this period of 29 months, the cones on the lopped branches yielded nine times as many seed as the felled trees and 100 times as many as the girdled trees, or 24.56 seeds per cone from lopped branches as contrasted to 2.87 seeds from felled trees, and 0.23 seed per cone from girdled trees. There were some variations between cages and between trees receiving the same treatments, but compared to the differences between treatments they were relatively small.

Of the total seeds disseminated, the lopped and scattered branches (slash) released 25 percent the first year, 68 percent the second year, and 7 percent the third year. The felled trees disseminated practically no seeds the first year and about equal quantities the second and third years. The girdled trees followed the same trend as the felled trees. July and August were the months in which most of the seeds fell (Fig. 2), although smaller amounts were also released during June, September, and October.

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[1]Maintained in cooperation with the University of Minnesota, University Farm, St. Paul, Minn.

[2]Acknowledgment is made of the helpful assistance of G. W. Kruse and W. R. Isaacson in the collection of data.

[3]Eyre, F. H. Dispersal of jack pine seed from seed trees and slash. Papers of the Mich. Acad. Sci., Arts. and Letters 21:279-284. 1935. Pub. 1936.

Factors Influencing Opening of Cones

A combination of low precipitation and high-temperature seems to be necessary to cause the cones to open well. The average seed fall per cone per day, the mean maximum temperatures, and precipitation by 10-day periods have been plotted in Figure 3 to show this relationship. The majority of the seeds fell during periods when the 10-day mean maximum temperatures were over 75 degrees, and within these periods seed fall was further affected by precipitation. The distance from the cones to the ground may also have influenced their behavior since temperatures on or near the ground surface are often higher than at a distance of several feet.

The effect of temperature and moisture on release of seed is perhaps best illustrated by the fact that, of the total yield from the lopped and scattered branches, 29 percent was obtained in the period July 11 to 21, 1936, 11 days of extreme drought and high temperatures. Much less seed was released during the summer of 1935, which was above normal in precipitation for northeastern Minnesota, and during the summer of 1937, when rainfall was about normal. Hence, it is likely that the amount of

Fig. 1.—Cones enclosed by window screen to measure seed fall.

seed that is dispersed during any particular summer is influenced by the rainfall and temperatures during that period. For example, if this experiment had been started in 1936 instead of 1935, the greatest yield of seed would probably have been obtained in 1936.

The effect of temperature was further shown by the fact that cones on the south sides of the felled trees opened more freely than those on the north sides.

The slowness with which the cones on the felled and girdled trees opened suggests that these trees, although dead, were still able to supply enough moisture to the cones greatly to retard their opening. This may have been a factor the first year, but was certainly much less so during the second and third seasons, since girdling, helped along by bark and wood boring beetles, resulted in the death of the trees in less than a year. Another explanation is that the cones may have dried so slowly that the positions of the scales became fixed by a process of "case hardening" such as sometimes occurs in lumber seasoning.

Seed Fall from Screened and Unscreened Cones

Although window screen reduces light intensity[4] and movement of air around the enclosed cones, the "catch" of seed in cages is believed

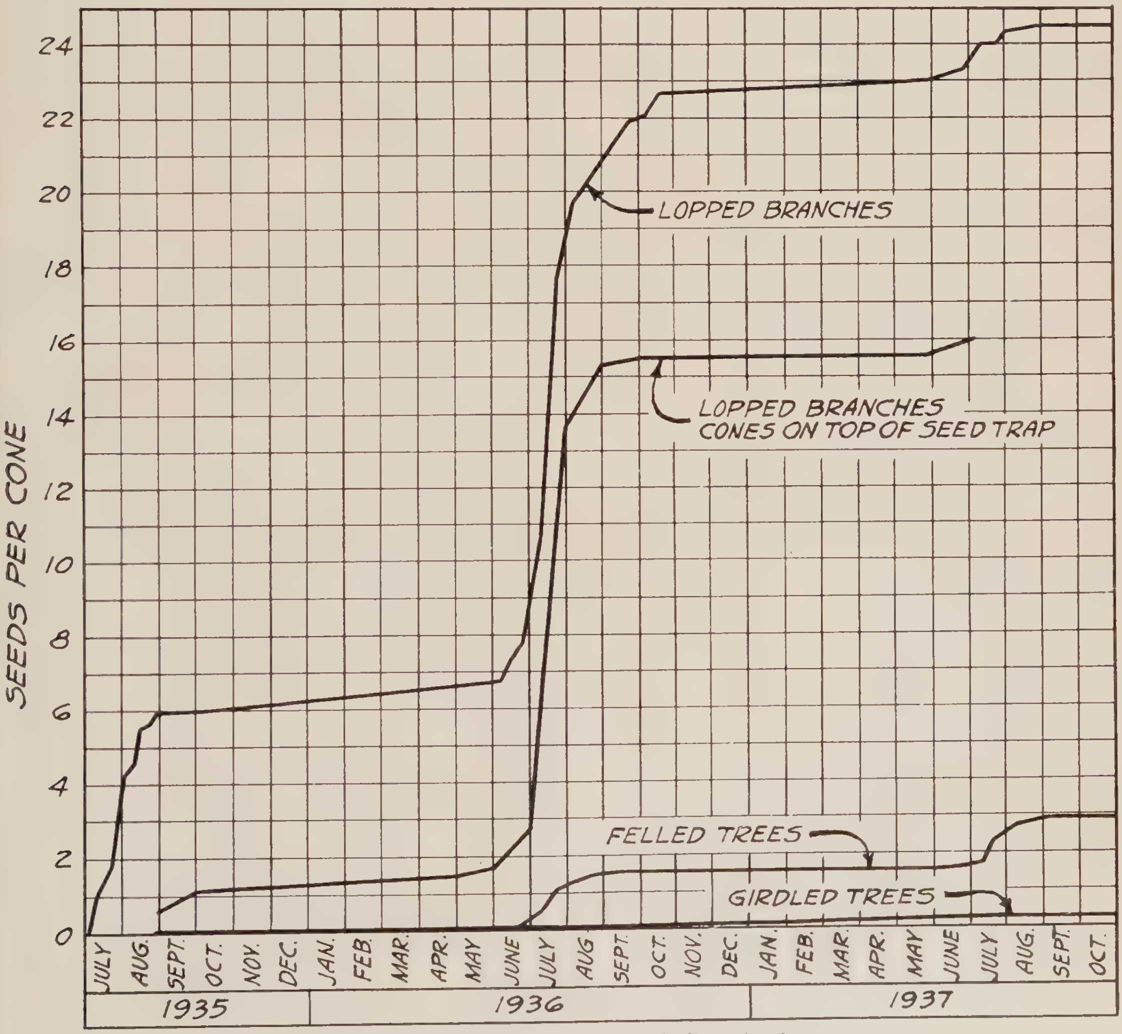

Fig. 2.—Cumulative record of seed dissemination.

[4]Light intensity is reduced 28 percent by common window screen. This was determined with a Shirley radiometer.

to be fairly representative of natural conditions. Cones outside the cages seemed to commence opening a little sooner than those inside, but during periods when the cones were most fully open, no difference in seed dispersal could be detected. Moreover, in connection with another study, cone-bearing branches placed on top of seed traps into which seeds could fall instead of inside cages gave very similar results (Fig. 2). The cones in the cages were shaded by the screen whereas those over the seed traps were shaded by a partial canopy of trees. The low yield of seed from cones over traps during 1935 was no doubt caused by the combination of tree shade and abundant rainfall. The reaction during 1936 was almost identical in the two tests.

Conclusions

1. The only effective way that has been found to release jack pine seeds from cones in connection with logging is to lop and scatter the branches. The cones on the lopped branches, however, do not drop all of the seeds in one year. It may be necessary therefore to leave the slash upon the ground for two or three

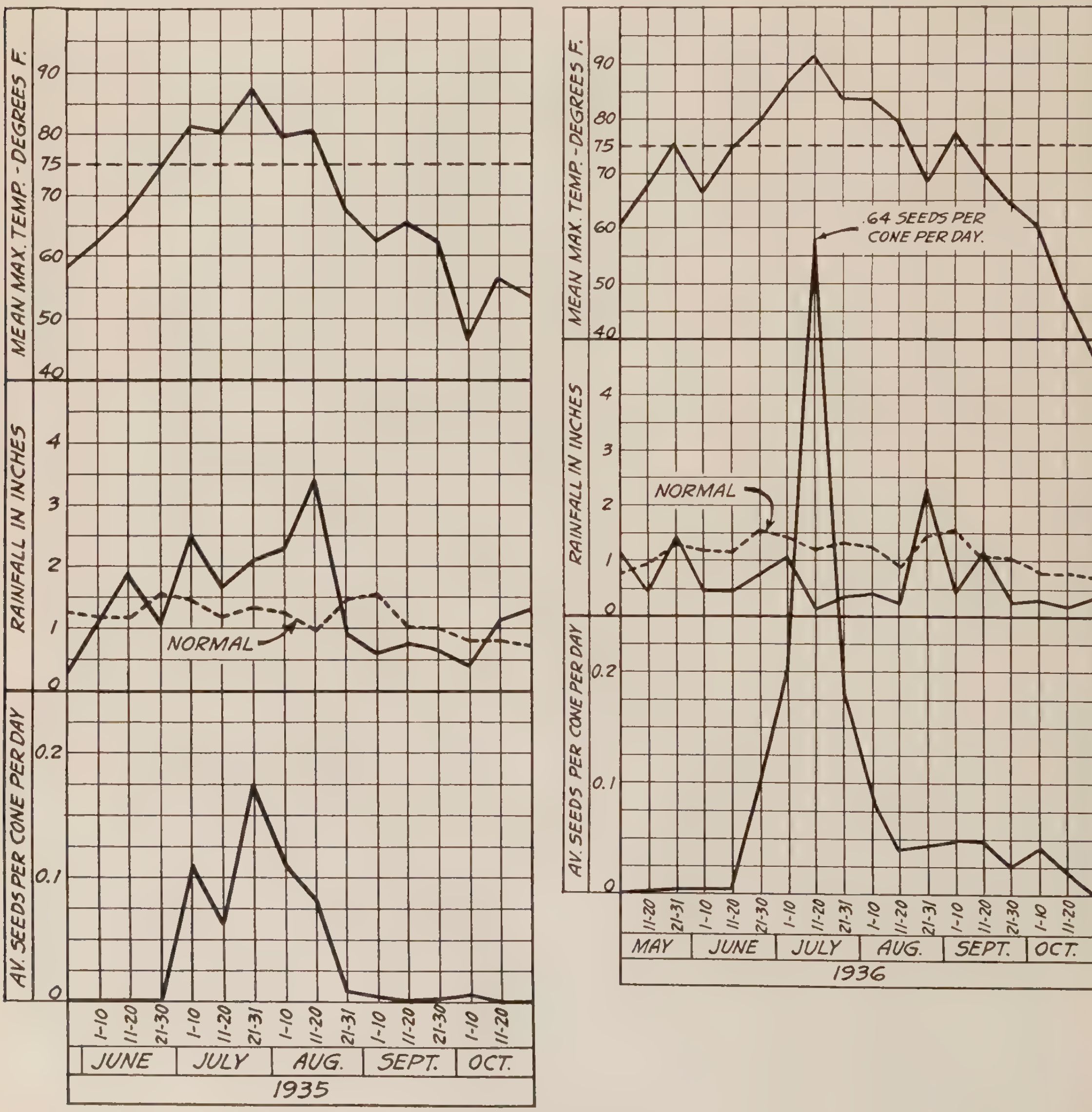

Fig. 3.—Relation of seed fall to temperature and precipitation.

years, depending on the weather, in order to obtain as many of the seeds as possible.

2. Seeds from lopped and scattered slash are most likely to fall during July and August. Jack pine seeds dispersed at this time are apt to germinate during the autumn rains and hence may be too small to survive the winter. If they do not germinate in the fall, they lie exposed to seed-eating creatures until the following May or June when germination conditions are favorable. Fortunately, from the point of view of reproduction, all dissemination does not occur in midsummer

3. This study, which showed that the seed fall from felled trees is very light, serves to explain in part the lack of jack pine reproduction in the blowdown areas caused by a severe windstorm which uprooted and broke many thousands of jack pine trees on the Superior National Forest in 1932. Since then there has been considerable speculation as to why almost no jack pine seedlings appeared in the devastated areas.

4. Since cones on jack pine trees killed by girdling do not release much seed, it is likely that the same is true for trees that have been killed by insects and drought. Trees killed in such a manner, therefore, cannot be depended upon to supply adequate seed for regeneration.

RELATION OF THE ROOT SYSTEM OF A SPROUTING STUMP IN *QUERCUS MONTANA* WILLD. TO THAT OF AN UNDISTURBED TREE

By O. M. WOOD

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The effect of any improvement cutting made within the extensive hardwood forests of the eastern United States may be destroyed by the ability of the component species to sprout. Sprouting indicates that only a portion of the root system dies when the parent tree is cut. This paper describes an attempt to learn how extensive this dying may be. A root crown ratio and the ratio between leaf area of the parent tree and that of the first year sprouts are also presented.

OVER one-half of the forest area east of the Mississippi River is occupied by hardwood stands of some description. One outstanding characteristic of the component species of these stands is their ability to regenerate by sprouts. This ability is a valuable asset in that it has prevented the extermination of some species over large areas following repeated cutting and burning. On the other hand this ability to sprout complicates *any* stand improvement measure which may be attempted in a hardwood stand, whether it be the one extreme of clear cutting followed by planting or any partial cutting down to the other extreme which removes only a few trees from the stand.

Regeneration by sprouts is, among other things, evidence that some part of the old root system continues to function after the removal of the parent tree. Silvicultural cuttings are made to reduce competition from either the residual stand or from the seedlings which may be planted after the cutting. Evidently when hardwoods are cut, although competition above ground may be completely removed, at least part of the root system continues to function. It is this continued root growth with the subsequent sprout development above ground which jeopardizes the success of stand improvement measures. However, little is known of the extent to which the old root system functions with the sprouts and even less is known of means for controlling sprouting. For these reasons, the Allegheny Station made the studies reported in this paper at the Camp Ockanickon Experimental Forest in the New Jersey Coastal Plain.

Field Methods

Selection of trees.—Since there is no way of studying the root system of a plant as large as even a small tree without destroying that root system, it was proposed that two trees, as near alike as possible, be selected. The root system of one of them would be excavated in its entirety while the other tree would be cut off

[1]Maintained by the U. S. Department of Agriculture at Philadelphia, Pa., in cooperation with the University of Pennsylvania.

TABLE 1.—DESCRIPTION OF TWO CHESTNUT OAKS USED IN STUDY OF ROOT SYSTEMS

Tree	Age at stump	Diameter at stump	D. b. h.	Height	Live branches from main stem	Leaves	Total leaf area	Dry weight stem	Dry weight leaves	Dry weight average leaf	Area average leaf	Approximate crown spread
	Years	*Inches*	*Inches*	*Feet*	*No.*	*No.*	*Square inches*	*Grams*	*Grams*	*Grams*	*Square inches*	*Square feet*
A	36	2.8	1.4	17.2	15	913	6380.7	2832	249.7	.265	6.99	22
B	33	2.1	1.3	14.2	12	623	5139.7	2141	224.3	.360	8.25	19
P	First year sprouts					85	666.4				7.84	

above ground and allowed to sprout. The following year the root system of this sprouting stump would be excavated and compared with that of the tree excavated a year earlier.

Obviously there are many serious objections to the use of this method, and these were fully recognized by the author. First, there is the difficulty of finding, in an unmanaged stand, two trees that are alike. Second, root habit is so unpredictable that even if two trees similar above ground are found, their root systems may be quite different. Third, the enormous amount of work involved in excavating one tree makes replications impossible hence description of results are case histories rather than the statistical analysis of data from an adequate sample. Fourth, no measurements of the root system of the stump, before treatment, i.e., before cutting of the parent tree, are possible. Fifth, and perhaps this is the greatest weakness of the method, no quantitative measure of the roots killed by the treatment is possible because these roots being extremely small will have decayed and disappeared in the interval between treatment and excavation. Sixth, a method which will permit the recording of all comparable data, must be devised for removing the roots from the soil.

In spite of these and other minor difficulties, it was believed that results, at least indicative of trends, might be obtained. The two trees, measurements of which are shown in Table 1, were selected. Both trees were of seedling origin.

These two trees were the nearest alike of any found, yet it will be noted that the one designated as "B" (the one to be cut and converted into a sprouting stump) was younger, smaller, and evidently somewhat more suppressed than the other. This difference is partly offset by the fact that the smaller tree had larger leaves. The smaller tree also had a more symmetrical crown radially as is shown in Figure 1. The ratio of root spread to spread of crown (229 to 22 square feet) for tree A has also been shown in this figure. A similar diagram could not be prepared for tree B because, as will be seen later, only a part of the root system of this tree was removed. The crown-root data for tree A has been included here because there are very few examples of this ratio to be found in the forestry literature, hence it is believed that it will be of general interest.

Methods of excavation.—These have been de-

TABLE 2.—COMPARISON OF SELECTED ROOTS FROM TREE AND FROM SPROUTING STUMP

Tree	Branch root No.	Length of main root	Total length of root and rootlets	Number of root branches	Total dry weight	Number dead ends
		Feet	*Inches*		*Grams*	
A	19	2.0	294.7	22	1.13	0
B	1	2.0	183.1	18	1.97	24
A	15	2.1	274.1	23	4.06	3
B	2	3.17	261.2	22	4.04	19
A	16	2.0	259.9	32	2.09	0
B	3[1]	1.9	152.8	32	2.87	6
A	36[1]	2.2	105.1	17	[2]	0
B	3[1]	2.2	120.3	19	[2]	30
A	21	0.9	14.7	0	[2]	2
B	4	1.0	13.4	0	[2]	1
A	28[1]	2.5	243.6	11	[2]	0
B	5[1]	2.4	238.7	10	[2]	9
A	24	1.6	85.4	10	[2]	11
B	8	1.1	60.6	6	0.45	1
A	30	1.6	265.1	24	1.22	0
B	12A	1.6	263.7	24	1.50	7
A	18	2.75	421.0	25	[2]	4
B	12	2.10	572.4	21	3.89	9
A	27	3.66	1128.8	44	7.72	0
B	13	3.75	687.8	34	6.89	22
A	Mean	2.13	309.2	20.8	3.24	2.0
B	Mean	2.12	255.4	18.6	3.45	12.8

[1]Part of root only used.
[2]Root not weighed separately.

scribed in an earlier paper.[2] Briefly, all roots were washed from the soil with a stream of water supplied by a hand-operated barrel spray-pump. It was suspected that any effect of the treatment would be apparent first in the root termini, hence a method such as this which would insure their removal intact was necessary. An abundance of water near the trees and the fact that they were growing in sandy, rock-free soil made washing an ideal method for the removal of their roots.

Records taken.—Although exact quantitative measurements of an object as irregular as a root are difficult to obtain, the following measurements were recorded as the roots were uncovered: depth of origin at the taproot, diameter at the taproot, depth below surface of root ends, distance to ends from taproot, and the principal compass direction of root from the taproot. Any unusual feature of the root was also noted. Some photographs were also taken during the progress of the washing.

As each root was removed from the soil it was pinned out in one plane, and photographed at a scale of about 1 to 5. Before photographing, all dead stubs, indicating where portions of the root had died and sloughed off, were marked with bits of black paper. As will be seen later these marks were the only measure obtained of the effect of the treatment. Active growing tips, indicating normal growth or regeneration of dead roots, were also marked where found. After photographing, the roots were oven-dried and weighed.

Following the above procedure, the entire root system of tree A, described in Table 1,

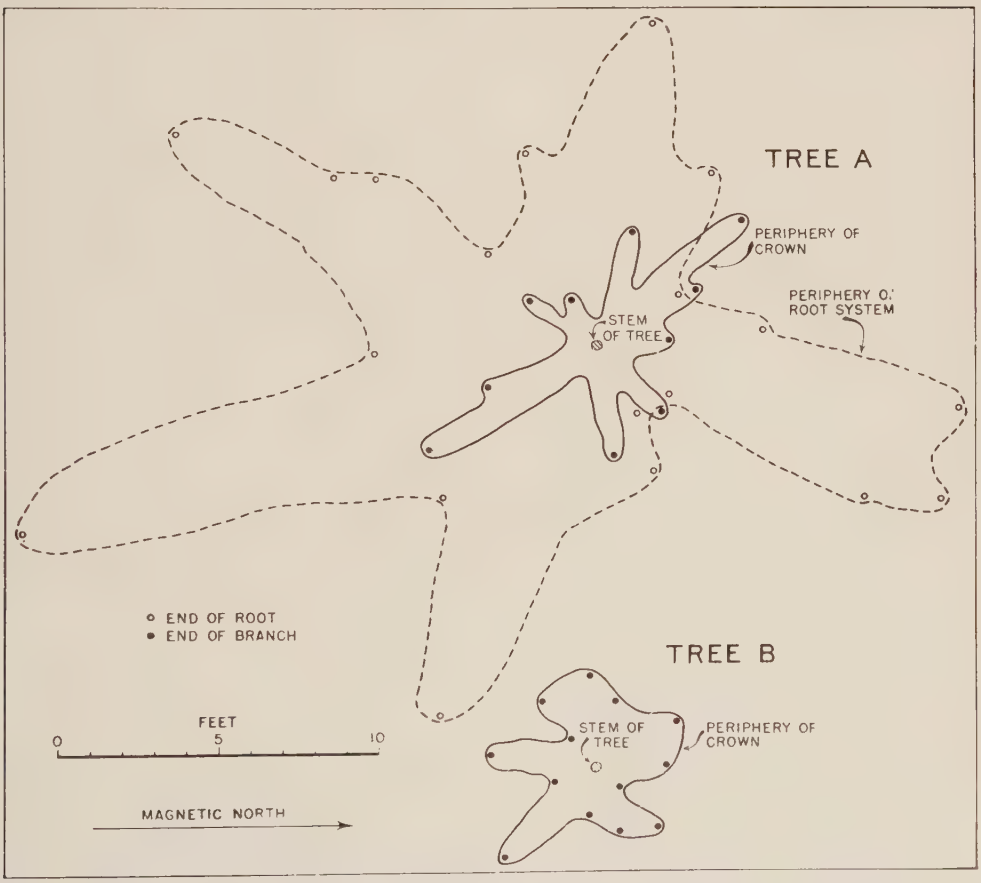

Fig. 1.—Diagram showing root-crown ratio of tree A and crown spread of tree B.

[2]Wood, O. M. The root system of a chestnut oak (*Quercus montana* Willd.). Proceedings 10th National Shade Tree Conference, 1934.

was excavated[3] and recorded. Prior to the beginning of the next growing season tree B in this table was cut at the ground level. About the middle of May, sprouts appeared and at the first of June three sprouts about 12 inches high had developed. At the end of September these and three more were 6, 12, 13, 18, 19, and 24 inches high, respectively. These bore 85 leaves having an area as shown in Table 1. It is significant to note that the first season's leaf area of the sprouts was only about 13 percent of that of the parent tree or inversely, the parent tree had a food manufacturing plant almost 8 times as large as that of the sprouts.

Late in September excavation of the root system of the sprouting stump was started. The same methods were used and the same records taken but limited funds permitted only the removal of 14 branch roots. These were the layer nearest the surface and completely around the stump.

Laboratory Methods

The laboratory task resolved itself into one of comparing the photographs and other records from each root system in order first to select similar samples, i.e., samples which would have the same inherent capacity to react to treatment and second, to note differences in the samples that might be ascribed to the treatment.

By casual inspection of the photographs, an attempt was made to match each root from the stump with a similar root from the tree using general size and form as criteria. Diameter of the root at the tap and total length, were used as measures of size, number of branches and area of spread as measures of form.

From this inspection, it was apparent that only 10 of the 14 roots from the stump, wholly or in part, could be roughly matched with roots from the tree. As a further check of similarity, the total length of these 10 pairs of roots was measured from the photographs, using an instrument having a roller geared to indicate distance on a dial, and commonly called a "map measure" (German, *Kurvenmesser*).

[3]An equal share of the field work was done by Dr. L. Edwin Yocum, Botany Department, George Washington University, Washington, D. C.

The comparative measurements of the 10 pairs of roots, including the number of dead ends, are shown in Table 2.

If it be granted from the data in Table 2, that the paired roots are reasonably similar quantitatively then the one outstanding qualitative difference, or the greater number of dead ends in the root system of the stump, may be ascribed to treatment or to the cutting of the parent tree. It is realized that a part of the root system of the stump might have been dead prior to treatment but it is believed that the ratio of dead ends, 20 to 128, is so great that it must be related to the cutting. Furthermore 11 of the 20 dead ends found in the root system of the tree occurred on one root. If this root were eliminated the ratio would be much greater. Further evidence that the death of the roots of the stump had been recent is found in the fact that the dead stubs were all small in diameter. If death of the roots from the tips back, had been progressive for a number of years, the dead ends would have been larger in diameter. Also there was no evidence of regeneration of dead tips in the root system of the stump. If death of the roots had occurred before the tree was cut some replacement of the dead roots might be expected since there had been no dying in the crown of the parent tree. There was evidence of regeneration and active growth in the root system of the tree excavated.

Conclusions

Although indirect and circumstantial, it is believed the evidence presented in this paper is sufficient to show that a certain portion of the root system dies immediately after the parent tree has been cut. What proportion this is could not be determined but since absorption is confined to the root tips and since these evidently die first, the absorbing surface lost must be great. It is known that the first year sprouts had a leaf area only 13 percent as great as that of the parent tree. Additional studies might show that there is some proportionate ratio between crown loss and death of the root system. They might also suggest means of destroying a larger part of the parent root system thus decreasing the ability of the stump to send out those sprouts which may jeopardize the success of most silvicultural measures undertaken in hardwood stands.

THE EFFECT OF SPACING ON THE GROWTH OF NORWAY PINE PLANTATIONS—A PROGRESS REPORT[1]

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Opinion concerning what constitutes proper spacing for coniferous plantations has changed considerably during the past thirty-five years. There appears to be a tendency to increase the spacing of coniferous plantations. Although the authors are not yet ready to draw final conclusions their work on sixteen-year-old Norway pine planted in Pennsylvania indicates that spacing up to 10 by 10 feet results in rapid diameter and height growth and may be advantageous when the trees can be pruned.

THE spacing of forest trees in plantations has received wide study by foresters over a long period of years. Since European practice in the nineteenth century was to use spacings as narrow as 1.25 meters or even less, the tendency of foresters in North America was to model early plantations on such standards with close spacing the rule. Kittredge (*11*) mentions the establishment of a number of coniferous plantations in 1889 near Ottawa, Canada. A progress report of these plantations, published fourteen years later Macoun (*13*) indicates that the closer spacings of 3 by 2 feet, which had been followed in the case of several species of conifers, were considered most satisfactory because of better soil protection and resistance to strong winds. The early *Forest Planting Leaflets* of the old Bureau of Forestry and of the Forest Service reflect this same belief in the efficacy of close spacing as a measure of soil protection and as an aid to natural pruning. The leaflet on Norway pine, for example, (*3*), advocates a spacing of 6 by 8 feet for Norway pine because of its intolerance, but a 4 by 4 spacing for white pine, a more tolerant species.

The early European viewpoint on the spacing of plantations was held over into the twentieth century as seen in the comments of such men as Frömbling (*2*) who warns against the growing tendency towards wider spacing of plantations on the grounds that it is contrary to nature. Nature provides for the successful establishment of the most vigorous trees by means of a struggle for survival between a great many individuals. Hence, a practice which lessens this struggle is unsound.

But the silvicultural advantages of close spacing, especially if early thinnings can be carried out, have been considered more recently as more than offset by the increased labor and planting costs and the decreased costs of the crop trees. More recent European views on the subject were summed up in a series of papers presented at the annual meeting of the Royal Scottish Arboricultural Society, (*20*). Results obtained from widely spaced plantations of rapidly growing conifers were cited as evidences of the desirability of such practice. It was stated that foresters in Great Britain were recommending the spacing of species such as Douglas fir 8 feet apart on good soil and 6 to 7 feet on soil of poorer quality. Another commentator points out the values of such open spacing on good sites with rapidly growing species and where natural pruning is not essential. Hiley (*8*) shows by tables the costs per acre of plants and planting at various spacing distances under British conditions. The costs are so much lower for wider spacings such as 8 by 8 feet that Hiley concludes that "unless early thinnings have a market value, spacing should be as wide as is silviculturally permissible."

Most recent practice in the United States shows on the whole the same trend toward the wider spacing of conifers which have formed the bulk of the planting stock. Toumey and Korstian (*19*) in discussing the spacing problem point out that "nearly all recent investigations demonstrate that the expense involved in the greater cost of close planting, in the necessity for early thinnings, and in the

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[2]The writers wish to acknowledge the work done on this study by A. C. McIntyre, formerly of the Pennsylvania State College, who collected and analyzed data in 1926, 1929, and 1932. They also wish to express their appreciation of the advice and assistance of H. A. Meyer of the Department of Forestry, the Pennsylvania State College, in the analysis of the data presented in this paper.

decreased growth of the crop trees is not justified." Baker (*4*) suggests that from the standpoint of merchantable-volume production a very large number of stems per acre is to be avoided. Hawley (*7*) states that in artificial planting "spacings not closer than 6 by 6 feet and not wider than 8 by 8 feet will be adopted in the majority of cases." Close spacing may be justified where early thinnings are practicable and where heavy losses in the original planting are expected. The strongest arguments in favor of wide spacing are the lower costs of establishment, the avoidance of early thinnings, and the increased growth rate.

There is still, however, quite a difference of opinion in the United States over what should be considered wide spacing. A spacing of 8 by 8 feet has been considered wide and foresters have warned against any further extension of this distance. It is recognized by the writers that wide spacing must be conditioned by a number of factors such as the form habit of the species planted, as well as their tolerance, the degree of ground cover, the condition of the soil, as well as on practical considerations of stand treatment and product desired, yet the grounds for setting a limit on the spacing distance for many species of forest trees do not appear to be well substantiated. More accurate data from field observations are required.

It was with the object of studying the ecology and growth of trees spaced at various distances on comparable sites that a series of four Norway pine sample plots were established in central Pennsylvania by the Forestry Department of the Pennsylvania State College in 1921. Norway pine is not native to central Pennsylvania, although it occurs naturally throughout the northern counties of the state and Illick (*9*) reports scattered stands as near as Selinsgrove, 50 miles away. The plots were 75 by 75 feet square, located on an upland old field site with an average slope of eight percent and a southwestern aspect. The soil is a Morrison sandy loam with a present pH averaging 5.13 and an average depth of about three and a half feet to bedrock.

The four plots were planted to Norway pine, 3-0 stock, in the spring of 1921, using spacings of 5 by 5, 6 by 6, 6 by 8, and 10 by 10 feet. Table 1 shows the degree of crown closure and natural pruning on the several plots as examined in the spring of 1932 and the fall of 1937. Complete crown closure had taken place on all plots except that containing the trees spaced 10 by 10 feet. On this plot the crowns touched, but large openings existed in the center of every four trees. In 1932 none of the lower branches had died. In 1937 natural pruning had taken place up to heights on the bole varying inversely with the spacing distance. A matter of interest in this connection is the diameter of the lower branches of the differently spaced trees, (Table 2). Branches of larger diameter as measured at a

Table 1.—Crown Closure and Natural Pruning

Spacing in feet

Year	5 by 5	6 by 6	6 by 8	10 by 10
1932	Crown closure. Forest floor shaded, no vegetation. Some of lower branches dead.	Crowns starting to close. Forest floor partially shaded. Herbaceous plants still present. Older foliage on lower branches dead.	Crowns starting to close where trees six feet apart. Some woody shrubs and herbaceous plants on forest floor. Older foliage on lower branches dead.	Crowns not closed—distance between, 2-6 ft. Shrubs and herbaceous plants present on open areas. All branches still alive.
1937	Crowns closed. All branches dead up to average height of 8.8 feet.[1] Thick mat of needles on forest floor.	Crowns closed. Branches dead up to height of 8.1 feet. No herbaceous vegetation present on forest floor.	Crowns closed where trees six feet apart. Partial closure where trees are eight feet apart. Natural pruning up to 6.2 feet. A few small shrubs still present on area.	Crowns touching but openings occur in center of every four trees. Trees had been pruned to 3½ feet. All branches living above that point although some needles on lower whorls were browning. A few shrubs and herbaceous plants present on the area.

[1]Distance measured to lowest living whorl.

Table 2.—Average Diameter of Base of Branches at Three and One-Half Feet Above Ground

	Spacing in feet			
	5 by 5	6 by 6	6 by 8	10 by 10
Av. diameter in inches	0.50	0.54	0.53	0.85

point next to the stem will make larger knots in the wood, an argument against wide spacing. Ten trees were selected in order on each plot and the diameters of the branches on the lowest whorl measured with a diameter tape. Since all trees had been pruned some years previously up to approximately three and a half feet, it was necessary to use this point as that at which measurements should be taken. The branches were dead on all but the 10 by 10 spacing plot at this height. The much larger branch diameters of the trees spaced 10 by 10 feet apart illustrate the limby character of these trees when pruning has not been practiced. Under intensive forestry practice such trees should be pruned up to ten or twelve feet before the lower branches reach such a large size.

In 1926, 1929, and 1932, five, eight, and eleven years after planting, all the trees on the plots were measured for height and, in 1929 and 1932, for diameter. Table 3 gives the average d.b.h. and average height of the trees for each spacing for those years. In 1926, the trees spaced 10 by 10 feet apart had not shown faster height growth than those in the other spacings, but by 1929 a slight superiority is shown which is more clearly expressed by the data taken in 1932. At that time the 10 by 10 spaced trees averaged 0.5 feet higher than the 6 by 6 spaced trees, the next tallest. Diameter data for the same years, 1929 and 1932, also show the superior growth of the widest spaced trees. It is of interest to note that there is no consistent relationship between width of spacing and height growth in the case of the 5 by 5, 6 by 6, and 6 by 8 feet spacing plots in 1926 and 1929.

In the fall of 1937 a detailed reexamination of the plots was made. Because of the presence of a large scarlet oak tree on the northwest side of the 5 by 5 spacing plot which overtopped a number of trees, it was necessary to eliminate these from the tally. All diameters at four and one-half feet breast height were measured with calipers to the nearest one-tenth inch. All trees were measured for height with a collapsible measuring rod graduated in tenths of feet. From these data the total height, the diameter, and the basal area of the average tree in each spacing was obtained, after separating the trees into one-foot height classes and one-half inch diameter classes.

Increment cores from twenty-five trees in sequence on each plot were obtained at six inch stump height and the annual rings measured with a traversing microscope and micrometer eye piece. Diameters at one-half above breast height were also obtained in order to compute an average form quotient. Table 4 gives the diameter and height of the average tree for each spacing with their standard deviations, the basal area for the average tree, and the form quotient. Figure 1 shows the annual radial growth for the four spacings over the period 1921-1937, and the annual precipitation computed from October of the previous year to October of the same year. Annual fluctuations in the growth rate appear to bear some relationship to fluctuations in the annual precipitation. The very wet year of 1927-28 followed by a comparatively dry period shows a particularly close relationship to the growth of the trees on all four spacing plots.

A comparison of the height and diameter data with that taken in the previous measurements indicates a consistent superiority in diameter and height growth for the trees spaced 10 by 10 feet. The more closely spaced trees are not only smaller in diameter than the widest spaced trees but they are also not so tall. The theory that close spacing tends to cause an increase in height growth at the expense of diameter growth does not appear to be true. This has been borne out by a previous study (*1*) of spacing relationships for jack pine. Both height and diameter growth were retarded where the stand was too dense. The same worker notes that Schantz-Hansen (*17*) in a study of overstocked red and jack

Table 3.—Height and Diameter Data from Previous Measurements

Spacing in feet.	Average d.b.h. inches		Average height feet		
	Year		Year		
	1929	1932	1926	1929	1932
5 by 5	1.25	2.25	4.9	8.0	12.8
6 by 6	1.35	2.59	4.8	7.5	13.2
6 by 8	1.45	2.49	4.3	7.8	12.5
10 by 10	1.51	3.01	4.9	8.1	13.7

pine stands found an increase in height growth as the density of a stand decreased. More recently Isaac (*10*) in an analysis of ten year's growth in Douglas fir plantations spaced 4 by 4, 5 by 5, 6 by 6, 8 by 8, 10 by 10, and 12 by 12 feet, found that the widest spaced trees, 10 by 10 and 12 by 12 feet, showed the greatest height growth, while the height growth of the trees in the narrower spaced plots exhibited no close relationship with width of spacing.

As is to be expected, the average form quotient of the trees spaced 5 by 5 feet is higher than that of the trees spaced more widely (Table 4). The widest spaced trees show the greatest taper. This is a factor which must be reckoned with in considering the value of wide spacing.

When the average diameter and average height of the trees in the different spacing plots are compared statistically (Table 5) by computing the standard error of the difference and applying Fisher's t-Test (*6*), the differences in all diameter comparisons are found to be highly significant. Height comparisons, however, are not significant as between the narrower spaced trees. Only when these are paired with the 10 by 10 spaced trees is there a significant difference. While the close correlation between diameter growth and width of spacing is strongly borne out, height growth is less affected by changes in stand density. It would seem that the comparatively small differences between the average heights for the various spacings indicate the validity of using height as the measure of site index.

It is evident from the results of the 1937 measurements that the trees spaced 10 by 10 feet average larger in size than those in the other spacing plots. The increment study shows a faster growth rate from the first growing season after planting to the present. The effects of root competition and other factors on the growth of the trees for each spacing is illustrated by the falling off of the growth rate from the peak reached in 1928 (Fig. 1).

When the basal areas for the trees on each of the four plots are computed on an acre basis, that of the closer spaced trees far exceeds the basal area for the 10 by 10 feet spaced plot. If the percentage ratio of the basal area per acre of the trees spaced 10 by 10 feet to the basal area per acre of the trees on the other plots is computed, however, for 1932 and compared with a similar ratio for 1937, the widest spaced trees show a marked increase in basal area during the past six growing seasons. For

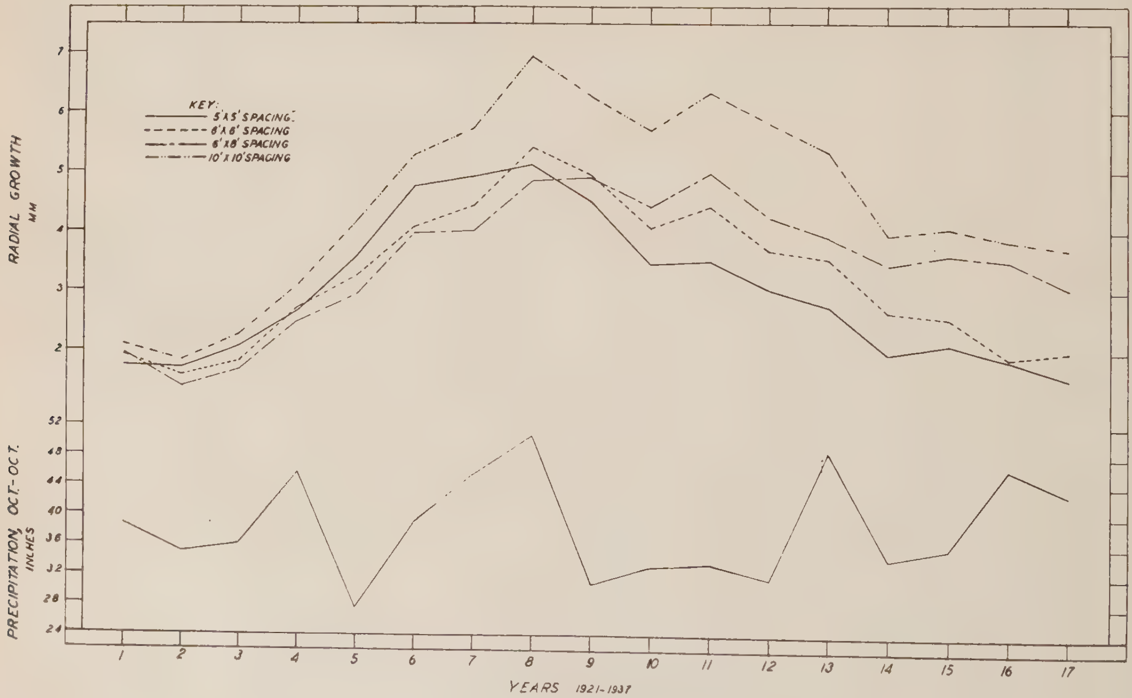

Fig. 1.—Annual growth of trees in the four spacings compared with precipitation for the period.

example, this ratio for the 5 by 5 foot spacing is 42.9 in 1932 and 54.6 in 1937, for the 6 by 6 foot spacing, 46.6 and 62.8 and for the 6 by 8 foot spacing, 62.4 and 66.2 respectively. This per acre increase in the basal area of the trees spaced 10 by 10 feet in relation to the other spacings will probably be even more marked in the future, as root competition and other limiting factors become more intense in the closer spaced plantations.

The data presented in this paper point to the tentative conclusion that under conditions of intensive management where pruning is to be carried out in two or three operations and where early thinnings are not likely to be profitable, Norway pine may be spaced as far apart as 8 by 8 or even 10 by 10 feet in view of the increased growth of the trees. The widest spacing under consideration, 10 by 10 feet, results in marked superiority as to growth rate but the greater taper of the stems and the large size of the branches may make this spacing unsuitable. It is too early in the life of the trees under study to reach definite conclusions. Further, similar spacing plots should be duplicated on other sites in Pennsylvania in order to provide adequate data for comparative study.

One further aspect of the problem deserves attention. Will the quality of the wood produced from these plantations be affected by the different spacing conditions? Paul (*14, 15*) has pointed out the relation between stand density and the specific gravity of wood for the southern pines and redwood. From studies made of these species he recommends a density of stands sufficient to narrow the ratio between spring and summerwood, in order to produce timber of sufficiently high specific gravity and uniform quality. On the other hand, Deen (*5*) in a review of the work done on this problem for northern white pine, concludes that there is no consistent relationship between specific gravity and rate of growth for this species. More recently Koehler (*12*) and Paul (*16*) have shown that the production of rapidly grown loblolly and slash pine is not desirable because of the excessive longitudinal shrinkage of this material causing bowing and crooking of the lumber product. Is fast growing Norway pine affected in the same manner? Studies are now under way at the Pennsylvania State College on this phase of the problem. Wood specimens have been obtained from Norway pine trees cut on each of the spacing plots. These will be given standard mechanical tests. An anatomical study of cell structure has nearly been completed. Periodic studies of a similar nature will be carried out as the trees on the spacing plots mature.

TABLE 4.—MEASUREMENTS OF THE AVERAGE TREE FOR EACH SPACING AND THE BASAL AREA PER ACRE—1937

Spacing in feet	D.b.h. inches M	σ	Height in feet M	σ	Basal area	No. of trees per acre	Basal area per acre	Form quotient (basis 25 trees)
5 by 5	3.72	±0.64	21.9	±1.97	.076	1742	132.39	.623
6 by 6	4.16	±0.83	22.1	±1.48	.094	1210	113.74	.610
6 by 8	4.49	±0.62	22.0	±2.17	.110	908	99.88	.615
10 by 10	5.58	±0.63	23.2	±1.66	.170	436	74.12	.557

TABLE 5.—COMPARISON OF THE DIFFERENCE BETWEEN SPACINGS

Comparison of spacings	Av. d.b.h. $\bar{X}-\bar{X}^1$	S.D.	Significance	Av. height $\bar{X}-\bar{X}^1$	S.D.	Significance
5 by 5 6 by 6	0.44	0.078	highly significant	0.20	0.20	not significant
5 by 5 6 by 8	0.77	0.076	highly significant	0.10	0.26	not significant
6 by 6 6 by 8	0.33	0.088	highly significant	0.10	0.75	not significant
5 by 5 10 by 10	1.86	0.091	highly significant	1.30	0.25	highly significant
6 by 6 10 by 10	1.42	0.101	highly significant	1.10	0.25	highly significant
6 by 8 10 by 10	1.09	0.100	highly significant	1.20	0.30	highly significant

SUMMARY

1. Problems relating to the spacing of forest trees in plantations are discussed. It is noted that there has been a general trend toward wider spacing, both in Europe and America largely because of lower initial costs.

2. Four spacing plots of Norway pine were established by the Department of Forestry of the Pennsylvania State College, in 1921 to study the effects of spacing on trees spaced 5 by 5, 6 by 6, 6 by 8, and 10 by 10 feet. The trees were measured for height in 1926 and for diameter and height in 1929, 1932, and 1937.

3. By 1937 crown closure had taken place on all but the 10 by 10 spaced plot. The crowns of the trees spaced 10 by 10 feet touched, but large openings occurred in the center of every four trees. Natural pruning up to a height of eight feet had occurred on the closest spaced plot but practically none on the widest spaced plot. Branch diameters of the widest spaced trees were over 50 per-cent larger than those of the trees spaced more closely.

4. An increment study at the time of the 1937 remeasurement showed the more rapid growth of the 10 by 10 spaced trees throughout the 17-year period under consideration. Growth was found to vary quite closely with the annual rainfall, calculated from October to October. The widest spaced trees averaged the tallest while there was little difference in height between the trees on the other spacing plots. A comparison of average diameters and average heights for each spacing showed highly significant differences in all diameter comparisons and in comparisons of the average heights of the more closely spaced trees with those spaced 10 by 10 feet. The average form quotient of the widest spaced trees is considerably lower than that of the trees spaced more closely.

5. When basal areas for each spacing are calculated on an acre basis, and the ratios of the basal area for the 5 by 5, 6 by 6, and 6 by 8 feet spacings to that of the 10 by 10 feet spacing in 1937 are compared with a similar ratio based on the 1932 measurements, the basal area for the 10 by 10 feet spacing appears to be increasing at a faster rate than that of each of the narrower spaced plots.

6. Because of the faster growth rate and resulting larger size of the trees spaced 10 by 10 feet it would seem that such wide spacing may be desirable where pruning can be practiced and where early thinnings are not practicable. The form of such widely spaced trees and the larger size of the branches are factors militating against wide spacing. This conclusion can be only tentative as the plantations studied are still immature. The question of the effect of spacing on wood structure and quality is being studied as a corollary of the problem.

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STUDIES ON *POLYPORUS ABIETINUS*. III. THE INFLUENCE OF CERTAIN FACTORS ON THE RATE OF DECAY OF LOBLOLLY PINE SAPWOOD[1]

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Laboratory studies of the rate of decay of wood by wood-destroying fungi have been made for a considerable number of years. The conclusions reached in many of the earlier studies are open to some question because the experimental data were not treated statistically. The influence of specific gravity on the rate of decay has been, and still is, a highly controversial question. The author's study shows that loblolly pine sapwood of high specific gravity is more resistant to decay produced by *Polystictus abietinus* than the same wood of low specific gravity.

THE relative importance of various factors which influence the decay of wood of a given species is a familiar subject of controversy among forest pathologists. Common sense and casual observation indicate that, within a species, wood of low specific gravity decays more rapidly than wood of higher specific gravity. Zeller (*6*) reached such a conclusion after measuring the loss in dry weight of loblolly, shortleaf, and longleaf pine heartwood decayed by *Lenzites saepiaria* (Wulf.) Fries. He found that no measurable factors could be correlated with decay in sapwood of these species of pines. Zeller's data were later subjected to statistical analysis by Buckman (*1*), who held that the conclusions reached by Zeller were not justified. Schmitz and Daniels (*4*) demonstrated that no relation exists between specific gravity and resistance to decay when woods from different genera are considered.

An experiment was set up, therefore, to determine whether certain measurable factor influence the rate of decay as induced by *Polyporus abietinus* (Dicks.) Fries upon loblolly pine sapwood (*Pinus taeda* L.).

Methods

Several hundred blocks, each ¾ by ¾ by 2 inches, were cut from fresh loblolly pine sapwood. After numbering them the specific gravity of each was obtained from its dry weight and its volume as measured by immersion in mercury. The percentage of summerwood was determined by photographing the ends of the blocks, projecting the negatives through an enlarger and measuring the width of the summer and springwood bands.

The blocks were sterilized in an autoclave for 45 minutes and placed in contact with vigorous cultures of *P. abietinus* growing on malt agar in liter flasks. Five blocks were placed in each flask. Care was taken to place the blocks so that their radial surfaces were parallel to the surface of the agar. The flasks were then divided into three equal lots. The first lot was removed at the end of four months, at which time the moisture content and loss in dry weight were determined for the blocks of each flask.

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[1]The writer is indebted to Prof. F. A. Wolf, who directed the research, and to Prof. F. X. Schumacher, who supervised the statistical analysis and made suggestions for revision of the manuscript.

A portion of a thesis submitted to the graduate faculty of Duke University in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

The moisture content at removal was taken as the moisture content throughout the period of observation, and the loss in dry weight as the measure of decay. Since decay had progressed so rapidly during the first four months, the second and third intervals were shortened, and blocks for the second and third lots were removed at the end of seven and ten months respectively.

The method of determining the rate of decay herein employed has been subjected to severe criticism, based mainly on the assumption that sterilization by steam under pressure brings about chemical or physical changes in wood which modify the growth of fungi. Such changes are postulated upon results of investigations by Schmitz (*3*), who found that sawdust of *Tsuga heterophylla* (Rafn.) Sarg. sterilized in an autoclave for 45 minutes lost 0.15 percent of its dry weight when exposed to the action of *Fomes pinicola* (Swartz) Cke., while sawdust not sterilized in an autoclave lost only 0.01 percent of its dry weight. It appears probable that the difference was due to removal of toxic water soluble or volatile materials during the sterilization. Evidence obtained by the present writer (*2*), however, indicates that there are no volatile or water soluble materials present in loblolly pine sapwood which are in any way inhibitory to the growth of *P. abietinus*.

Measurements and Analyses of Results

The average measurements for the three periods of observation are presented in Table 1. Complete data on individual blocks are not presented, but they are available should anyone desire to consult them.

As the most pronounced changes are to be expected with long exposures, the data of the final period were subjected to a preliminary analysis designed to test whether the contribution of each of the measured factors—or indipendent variates—to the decay of loblolly pine is significant.

The analysis is a natural outcome of simple and convenient classification of information contained in the observations, viz: (1) The variation of loss in dry weight, (2) the corresponding variation in the independent variates, and (3) the covariation between loss in dry weight and each independent variate, and among the independent variates themselves.

From the classification may be calculated the "regression" of loss in dry weight on one or more of the independent variates; if significant, the corresponding "regression coefficient" is in itself a statement of the average additional loss in dry weight associated with each additional unit of the correlated factor.

The classification consists in segregating two separate classes of effects. The first of these is the variation of individual blocks around the mean values of their own flasks; and the second is the variation of flask means around the general mean of the flask means. Expressed in sums of squares their total is the sum of squares of individual blocks values around the general mean.

The regression based upon variation among blocks of the same flask was found to be not significant, due mostly to the very consistent moisture content—as expected—between blocks which had been together in the same flask during a period as long as ten months.

The regression based upon variation among flask means, however, is highly significant of real effects ascribable to moisture content and specific gravity, although that ascribable to percentage of summerwood, independent of specific gravity, is both negligible in amount and indistinguishable from mere chance effect. This variate is, accordingly, dropped from further consideration.

Regressions of loss in dry weight on moisture content and specific gravity of flask means were next calculated for (1) the four-month, seven-month, and ten-month periods separately; (2) the combined data of these three periods but exclusive of that part due to variation among period means; (3) the combined values of the three periods and including variation among period means.

Table 1.—Average Effect of *P. abietinus* on Loblolly Pine Sapwood by Periods, With the Averages of Measured Factors

Period of growth	Percent loss in dry weight	Percent water at removal	Percent of summerwood	Specific gravity	Number of flasks
0- 4 months	20.15	131.15	31	.4385	27
0- 7 months	37.31	139.23	31	.4396	26
0-10 months	43.62	142.85	36	.4396	26

Sums of squares of loss in dry weight independent of moisture content and specific gravity variates used in these several regressions supply the material for making pertinent tests, as given in Table 2. The total sum of squares of the bottom line is that which is independent of the regression under (3) above, including variation among period means. Subtracting therefrom the sum of squares independent of the regression under (2) above, from which the variation among period means has been excluded, the residue is due to differences among period means. It is listed in the first line of Table 2. Except for experimental error this value would obtain under constant conditions of the independent variates used. The combined sums of squares independent of the individual period regressions under (1) above supplies the experimental error, for it is freed of variation among period means. Subtracting it from the sum of squares independent of the common regression under (2), the residue is due to differences among period regressions, listed in the second line of Table 2.

Mean squares of each classification are also listed. If there were no significant differences among the period means, or among the period regressions, these mean squares would be approximately the same as the means square in experimental error, i.e., 47.4; and a ratio of either of the former to the latter—designated *F*—would therefore be approximately 1. Under such conditions, values taken from the distribution of *F* (5) in random samples as given in the last column of Table 2 would be expected but once in 100 such sets. By comparison the observed values of *F* in the next to last column are greater. The observed differences among period means as well as among period regressions are, consequently, adjudged highly significant. Therefore the proper expression of loss in dry weight, in terms of the measured factors, depends upon the period of exposure under consideration. These are the following:

4 months' regression: $Y = 20.15 - 0.1072\ (X_1) - 0.3504\ (X_2)$
7 months' regression: $Y = 37.31 - 0.0545\ (X_1) - 0.1984\ (X_2)$
10 months' regression: $Y = 43.62 - 0.0957\ (X_1) - 1.7720\ (X_2)$

In which Y is percent loss in dry weight.
X_1 is deviation from period average of percent of water in blocks at removal.
X_2 is deviation from period average of specific gravity of blocks.

An interpretation of these equations is best obtained by examining one of them in detail, as for example, the equation for the four months' period. At the end of four months the average loss in dry weight was 20.15 percent. This average loss in dry weight is associated with certain average values for specific gravity (Table 1). During this period, however, those blocks which were of average specific gravity, but above the average in moisture content, decayed less rapidly than those of average specific gravity and of average or below average moisture content. Consequently the coefficient of loss in dry weight on moisture content is a negative number (—0.1072), showing that among blocks of uniform specific gravity the average loss in dry weight is 0.1072 percent less for each additional percent of moisture. The coefficient of regression of loss in dry weight on specific gravity is also negative (—0.3504), showing that among blocks of uniform moisture content the average loss in dry weight is 0.3504 percent less for each additional unit of specific gravity. The regression coefficients for the seven month period are also negative, but those for the ten month period are positive. With these regression coefficients determined, therefore, it is possible to predict what will be the loss in dry weight of a block of known specific gravity and known moisture content.

Figure 1 presents the graphical representations of the regression coefficients for the three observation periods. Since Table 2 has shown that the differences among period means as well as among period regressions are significant, the graphs are, therefore, justifiable.

Discussion

The results obtained with decay of loblolly pine sapwood by *P. abietinus* recall the original, and frequently disputed, contention that specific gravity is an index of durability. Statistical analyses are included to show, in the case of loblolly pine sapwood, that specific gravity affects decay as caused by *P. abietinus*. It is not probable that sterilization of the blocks alters the effect of specific gravity.

The graphs contribute other interesting features. Figure 1 *A* indicates that decay becomes less per unit of time as its process proceeds. This is not unexpected. Figure 1 *B* indicates that during the first seven months the average

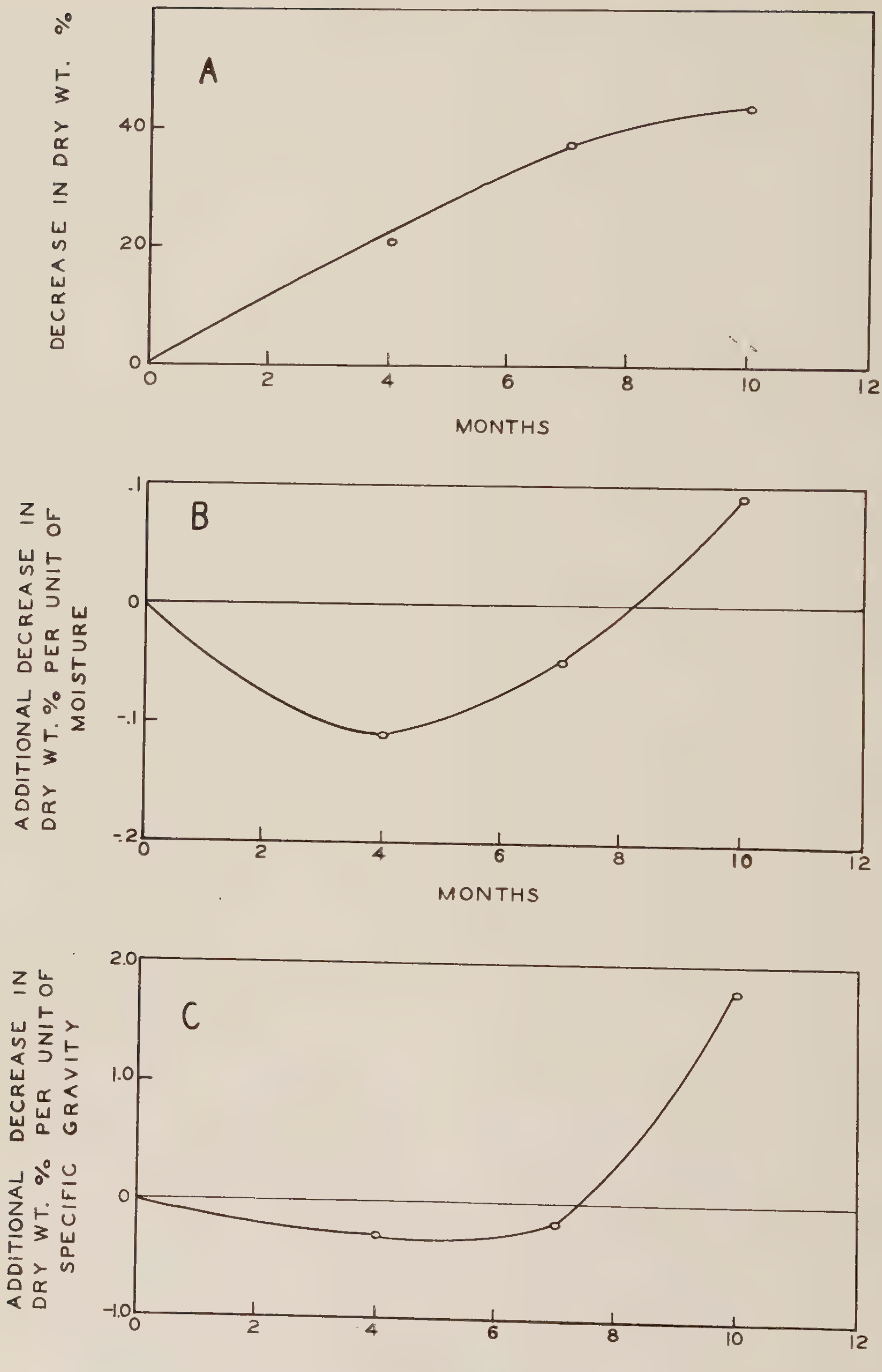

Fig. 1.—Effect of time on decay of loblolly pine sapwood by *Polyporus abietinus*.

A. The average loss in dry weight as affected by time.

B. The regression coefficients for moisture, showing the average effect of an additional unit of moisture in producing additional loss in dry weight for constant specific gravity.

C. The regression coefficients for specific gravity, showing the average effect of an additional unit of specific gravity in producing additional loss in dry weight for constant moisture content.

TABLE 2.—ANALYSIS OF VARIANCE OF ADJUSTED VALUES OF LOSS IN DRY WEIGHT, INDEPENDENT OF REGRESSION ON MOISTURE CONTENT AND SPECIFIC GRAVITY

Variation due to	Degrees of freedom	Sum of squares	Mean square	Values of F	
				Observed	Expected[1]
Period means	2	7698.25	3849.0	81.20	4.92
Period regressions	4	871.39	217.8	4.59	3.60
Experimental error	70	3219.31	47.4		
Total	76	11788.95			

[1]At 1 percent level.

moisture content of the blocks was above optimum, since additional moisture would have decreased the amount of decay. The average moisture content during the four to seven month period was more nearly the optimum than during the first four-month period. At the end of the ten-month period the average moisture content was below the optimum. This occurred in spite of the fact that, due to increased water retaining capacity as a result of decay, the average moisture content at ten months was higher than at four or seven months. Figure 1 *C* indicates that during the first seven months if the specific gravity of the blocks had been higher the loss in dry weight would have been lower. Therefore, blocks of high specific gravity are more durable. The additional decay with increased specific gravity at ten months, in all probability, is due to the fact that the decay has progressed to the point at which all of the springwood has been destroyed, and the summerwood is being decayed. Increased specific gravity would increase the material on which the fungus could act.

The lack of correlation between percentage of summerwood and decay is not due to error in measuring the summerwood, but indicates that specific gravity is the factor which influences the rate of decay and not the closely associated factor, summerwood percentage.

SUMMARY

Analyses of results of decay of loblolly pine sapwood by *P. abietinus* indicates that both specific gravity and moisture content of the wood are significant in determining the rate of decay. The relation between moisture content and decay is a conclusion generally accepted without question. The relation between specific gravity and decay, however, has been seriously questioned.

From the present experimentation it is concluded that the higher the specific gravity of a piece of loblolly pine sapwood the more resistant it will be to decay produced by *P. abietinus*.

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MEASUREMENT OF PRECIPITATION ABOVE FOREST CANOPIES[1]

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Determination of the precipitation-run-off relationship, and of the conditions governing it in areas under various types of forest cover, is becoming the focus of much attention by conservation workers in an effort toward better coordination of land management practices for regulation of water yield, control of floods, and reduction of erosion. The interception of rainfall by the forest canopy is undoubtedly responsible for some of the regulating and reducing effect that forests are known to exert on run-off. This paper discusses the degree to which interception of rainfall by the forest canopy may modify the run-off relationship, and presents a method by which rainfall may be measured at the tree crown surfaces in order that true values will be established in the determination of the role of forest cover in controlling run-off.

MANY measurements have been made in various parts of the world to ascertain the amount of rainfall intercepted by forest canopies and the extent to which conditions of the stand, character of precipitation, and atmospheric factors govern the amount of this interception. In most of these studies several rain-gages have been placed in representative locations under the forest canopy and the average of these gages compared with the catch of one or more gages located in a nearby open area.

Simson (*22*) reports an average penetration of 66 percent of the actual rainfall in a stand of Douglas fir and Phillips (*21*), working in South Africa, states that 78 percent of the average rainfall reached the ground under Knysna forest, while Wood (*23*) obtained the highest average penetration of any of the studies reported with a value of 87 percent under a mixed conifer-hardwood canopy. From measurements made under an oak forest Holch (*14*) found 84 percent of average rainfall reaching the ground, and 73 percent penetration under a linden forest with a greater density of canopy. Data by Burger (*6*) show rainfall penetration averaging 52 percent in a spruce stand and 69 percent under a beech canopy, with winter penetration remaining virtually the same in the spruce, but increasing to 82 percent in the beech. Beall (*3*) used a stand of pine and a stand of hardwood in which the crown densities were about equal, as measured by the Clements photometer, and found an average of 60 percent penetration of the rainfall under the pine and 80 percent under the hardwood, but reports no appreciable difference in winter interception by the hardwood canopy. In measurements made by Horton (*15*) the ground rainfall measurements were corrected to include the amount of water running down the tree trunks. With stemflow taken into consideration he reports a penetration of only 60 percent of the average rainfall with somewhat greater interception by conifers than hardwoods and a very measurable falling off in interception by the hardwoods after falling of the leaves. For rainfall of small amounts, Mitchell (*19*) found only 54 percent penetration, which increased up to 90 percent for heavy storms. From a study at the Lake States Forest Experiment Station (*1*), it was estimated the rainfall penetration of average stands is 60 percent for rains up to .05 inch, 70 percent up to .1 inch, 80 percent up to .3 inch, and an increase of 2/3 of 1 percent for each additional .1 inch of rainfall.

The interception ratio is seen to decrease markedly after the storage capacity of the foliage has been satisfied. For this reason the intensity maximums and total amount of the large storms may be little modified by interception and as a result the rainfall retained by the crowns may not be an important factor in the run-off flows from the big storms. Hirata (*13*) made measurements at 12 forest meteorological stations in Japan with from 5 to 10 gages at each station, and found for a 3-year period an average interception of about 20 percent of the total rainfall, of which 15 percent was retained in the crowns and evaporated directly therefrom and about 5 percent ran down the trunks. His data show a seasonal variation of approximately 10 percent which he attributes mainly to the character of the pre-

[1]Contribution from the California Forest and Range Experiment Station, U. S. Forest Service, Berkeley, Calif.

cipitation during the respective seasons. The interception was uniformly greater with conifers than with broadleaved species. He makes the noteworthy observation that trees on a slope have more stemflow than those on level areas due to the tree receiving rain from both the top and sides. In reviewing early European studies Harrington (*12*) states that the rain caught annually under trees in Germany varied from 89 to 52 percent of that in the open with a mean of 75 percent. Of the sixteen stations from which these data are taken 10 of them did not vary more than 5 percent of the mean. He also quotes a 42-year record of three Swiss stations which averaged 90, 84, and 77 percent of the precipitation reaching the ground. No association between seasonal stage of the foliage and amount of interception was found in these studies, although the amount of interception was indicated to be affected by temperature as higher interception occurred during warm weather. The average stemflow was determined to be approximately 8 percent. Some discussion arose in earlier work as to whether the amount of precipitation is influenced by height above the ground thus rendering the difference in amount of rainfall at the surface of the forest canopy and at the ground beneath not entirely due to interception. Measurements were carried out by use of scaffolds and towers to determine the amounts of precipitation at various heights above the ground. Blandford (*4*) found rain gages at the ground averaged 3 percent more rainfall than gages about 60 feet in the air. Abbe (*2*) concludes this difference is due to wind velocity and Brooks (*5*) supports this assumption in his comment that the catch of gages over forested areas may show higher readings than corresponding gages in the open due to reduced wind velocity prevailing at the surface of the forest canopy.

Corresponding results are reported in several additional investigations (*7, 8, 9, 10, 11, 16, 17, 18, 20*) which have dealt directly or indirectly with rainfall interception by various types of vegetation. The foregoing studies, though not significant on an area basis, indicate that from 1/5 to 1/3 of the total precipitation is intercepted by the forest canopy. The type and density of the foliage, and the intermittency of the rainfall, largely determine the portion of the rainfall intercepted. The maximum interception capacity of the foliage for a single storm is shown to vary from a few hundredths of an inch to over .5 inch conditioned, in addition to type and density of foliage, by the duration of the storm and the evaporation rate as governed by temperature, humidity, and wind velocity during its continuance.

A means is needed for convenient sampling of the precipitation at the tree crown surface if a true hydrometric evaluation is to be made of the forest either as overall rainfall-run-off ratios or interception determinations as part of a factorial breakdown of the component influences within the forest. The method used must enable randomized placement of the gages in order that a valid basis be provided for computing the reliability of the estimate made from the sample. Randomization of the gages does not permit selection of sites for location of towers and platforms, or pruning of the vegetation. The reliability of the estimate, in turn, is controlled by the number of gages used, and because of the extensive replication of gages which is often necessary when precise estimates are needed the plan must also be convenient and economical to operate.

Design

The following method for sampling of precipitation at the tree crown surface is believed to fulfill the requirements. A hoist mechanism, mounted on the top of a pole, and operated from the ground by means of a cable, is used to elevate the rain gages to position. It is so designed that the gages are thrust vertically above the hoist by a continued pull on the raising cable. The clearance of the gage above the hoist is sufficient to allow removal of the funnel for snow catch. Provision is made for the operation of the hoist under ice-storm conditions.

The simple construction of the hoist is shown in Figure 1. The cable is seen to pass through two pulleys one of which serves in elevating the gage to the hoist and the other, upon contact of the gage, acting as part of a lever mechanism which transmits the pull of the cable to a thrust action and elevates the gage to a final position. Views of the hoist with a gage in lowered and in raised positions are shown in Figures 2 and 3. The bail, to which the

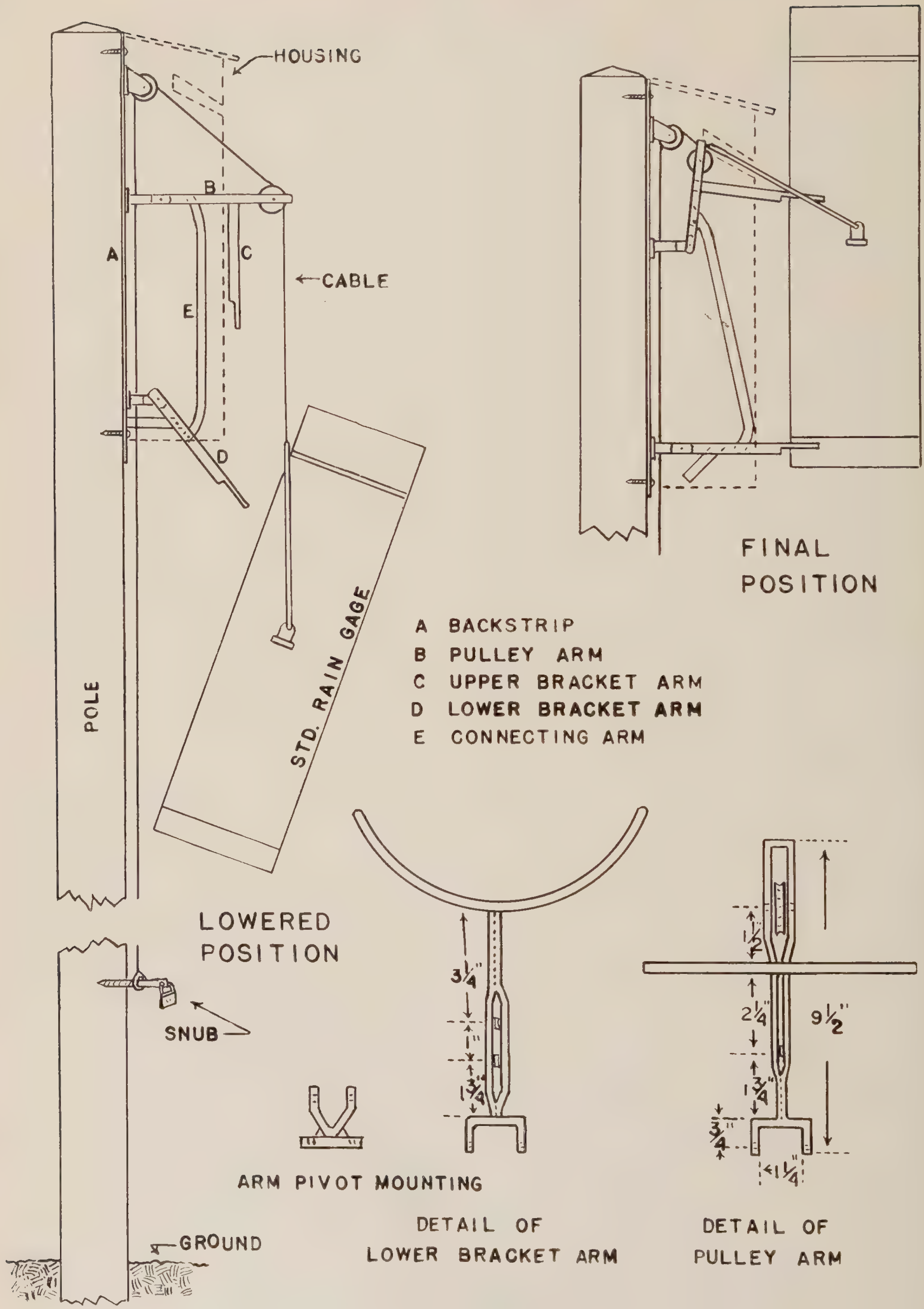

Fig. 1.—Sketch of construction detail of hoist.

cable is attached, is mounted on the gage about half way down from the rim in order to enable sufficient elevation of the gage to clear the hoist mechanism. An iron ring, as shown in Figure 4, is attached to the bottom of the gage as ballast to prevent its tipping upside down. The gage is held in final position by snubbing the cable to the base of the pole. A padlock may be placed through the snub shank to prevent tampering with the gage.

The material used in the hoist is ordinary strap iron, size $\frac{5}{8}$ by $\frac{1}{8}$ inch for the arms, and 3 by 3/16 by 24 inches for the back-strip on which the arms are mounted. The upper arm is located $10\frac{3}{4}$ inches and the lower $19\frac{5}{8}$ inches from the top of the back-strip. The dimensions and construction of the arms are shown in Figure 1, with the exception of the upper bracket arm, which measures 6 inches from the pulley arm to the inside of the gage bracket and the connecting arm which is 12 inches from pin to pin and shaped as shown. The cable is 3/32-inch phosphor bronze tiller rope. The bail is made from a $\frac{1}{4}$-inch iron rod and has a radius of 11 inches. The pivot of the bail is mounted 14.2 inches from the bottom of the gage. Cotter pins are used to prevent the bail from coming out of the pivots. The moving parts of the hoist are enclosed by a housing made of 26-gage galvanized iron as a protection during ice storms.

Operation

The hoist may be installed at any given location and operated to any height desired. Wood poles are recommended for use in elevations up to 35 or 40 feet and 2-inch iron pipe for the higher elevations. The poles will need to be braced with 3-way wire guys at one or two places up the pole. The hoist is mounted to the wood poles by four screws placed through holes provided in the back-strip. Bolts with clamps are used for mounting the hoist to iron pipe.

An auxiliary rope, which may be snapped in the snub-ring on the end of the hoist cable, is carried from pole to pole for use in raising and lowering the gages. The angle of the lower bracket arm is such that the gage is automatically guided into proper position in the hoist regardless of the direction it may face while being raised. In localities where extreme ice conditions occur a hasp loop may be soldered to the bottom of the gage and a rope left hanging to it for pulling the gage loose if it becomes stuck. It is doubtful if this will be necessary even under severe conditions since the gage is not in sliding contact with any part of the hoist during raising or lowering. The supporting arms have a lever-like action against the gage and for this reason the weight of the gage and contents, when released for descent, is sufficient to break any normal coating of ice.

The method for tree-crown precipitation gaging herein described has been in operation since 1934 at two locations in California, one on the San Dimas Experimental Forest where it was first used, and the other in the Sierras near Bass Lake. Since snow occurs at both these locations an opportunity has been afforded to test thoroughly the functioning of the method in weather conditions of varying character.

The test units of this device were constructed under the direction of H. M. Whitecar, sheet metal foreman, Munger & Munger, Pasadena, Calif.

Summary

The amount of precipitation intercepted by forest canopies is indicated by various investigations to be from 1/5 to 1/3 of the total rainfall. The interception of rainfall by the tree crowns may, therefore, play an important part in the rainfall-run-off relationship of areas under forest cover. Much attention is being given by many investigators to an evaluation of this relationship, and in order that true ratios may be established a means is needed by which the precipitation can be measured at the surface of the forest canopies.

A method for tree-crown precipitation gaging is described. It employs a simple hoist device which may be mounted on the end of a pole and with which gages may be raised and lowered from the ground to crown-surface position. The gage clears the hoist sufficiently to allow removal of the funnel during snow periods and the hoist is designed to operate under ice-storm conditions. The method allows fulfillment of the statistical requirements for sampling of rainfall and is convenient and economical to operate. It has been in successful use for four years in a broadleafed and a coniferous

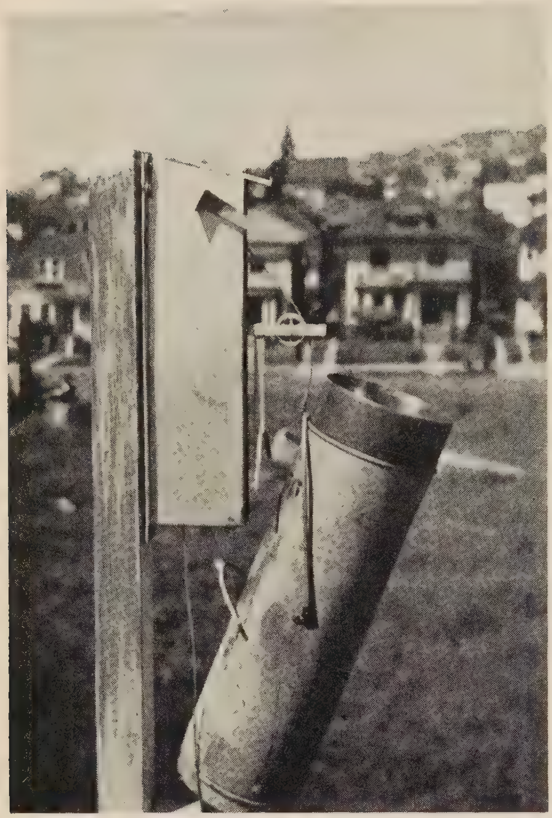

Fig. 2.—View of gage hoist with gage in raising position.

Fig. 3.—View of hoist and housing with rain gage in final position.

stand under a wide range of weather conditions.

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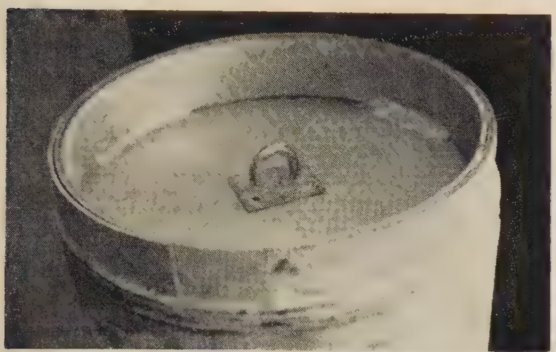

Fig. 4.—View of ballast ring and rope attachment on bottom of rain gage.

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American Elm Beset With Another Epidemic Killer

THIS country's most esteemed shade tree, the American elm, is now beset with another epidemic killer—a virus disease. Pathologists in the Federal Bureau of Plant Industry find it has killed thousands of elms in the past few years in the middle and lower Ohio Valley. First indications of the disease are a slight shriveling and brittleness of the leaf, accompanied by a rotting of the roots and the inner bark of the trunk. Within a few months the tree may be dead.

This is the first time a virus diseas has become an epidemic killer on forest or shade trees in this country. When the Bureau specialists could find no organism responsible for the disease, they proved it a virus by grafting scions from diseased trees to healthy trees. In a number of cases the healthy tree was infected. The proof that such a disease—in which the organism or causal agent cannot be filtered out or seen under the microscope—will kill forest and shade trees in an epidemic way may open a new field in the study of tree diseases. They hope next to determine how the virus is spread and what may be done to combat it.

TESTING GERMINATION IN SAND

By A. A. DUNLAP AND A. D. McDONNELL
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A new method is described for testing the germination of tree seeds. The method is simple and may prove useful to foresters and nurserymen.

SEEDS of forest trees are relatively slow in germination. Consequently, many methods have been devised for testing their germinative capacity. Because of the time involved, an accurate method that requires the least attention would be most desirable. In the course of experiments dealing with the control of damping-off of seedlings by sand culture, favorable germination of several different kinds of forest tree seeds has been easily obtained. This simple method, which may prove useful in ascertaining the viability of the seeds of many tree species, is here described. It should be stated, however, that this report is based upon preliminary trials and is being presented with the suggestion that the method be further tested.

The method somewhat resembles one mentioned by Toumey and Korstian (*5*) in which the seeds were placed in soil, covered with sand, in flower pots placed in a shallow container of water. After several years of experimenting, we prefer clean sand instead of soil because of the occasional presence of damping-off fungi even in sandy soils from non-cultivated areas. In flats that were watered from above in the usual manner, Boyce (*1*) obtained a somewhat higher germination percentage of Douglas fir seed with sand than with loam or loam-sand mixture, and noted several other advantages in using pure sand. In testing the germination of certain coniferous seeds Larsen (*4*) obtained more favorable results in the Jacobsen germinator than in sand. Larsen, however, placed a layer of coarser sand in the bottom of the tray for drainage, and the sand was watered with a hand sprinkler using small quantities of water which were "applied only after the upper part of the sand began to show signs of drying." Dunlap (*2*) found that soils which were treated with formaldehyde or steam did not produce as good a stand of red spruce seedlings as was obtained in sand under the same conditions. Traces of the disinfectant remaining in the soil, or changes in the soil through heating, have been known to impair the germination of many kinds of seeds.

The important advantages of the method are as follows: (1) apparently poor germination because of damping-off fungi in the germinating medium is avoided by the use of partially sterile sand and saprophytic molds have not been found troublesome, (2) little attention is necessary, (3) the necessary equipment is simple and inexpensive, (4) by providing the cultures with continuous sub-irrigation, the necessary moisture is automatically supplied to the germinating seed, and (5) moist sand that is well aërated seemingly provides ideal conditions for germination—possibly closely resembling favorable conditions in the field.

The general procedure has consisted in filling a 7-inch flower pot nearly full with fairly coarse, clean sand. A definite number of seeds (from 50 to 500, depending upon size) are then spread over the surface and covered with one-eighth to one-fourth inch of sand. The pot is then thoroughly wetted and placed in about an inch of water in a shallow container. The water should be deep enough to make contact with the bottom of the sand mass in the pot. (A small stone or piece of wire screen may be placed over the hole in the flower pot to prevent the sand from washing out.) This setup may be made in a greenhouse or even in an ordinary laboratory room or basement. In climates or seasons that are free from freezing temperatures, the cultures may be kept out of doors either with or without the protection of a roof or shading. The only attention that is necessary in running the tests is to add water to the container in which the pots are standing. This care is not exacting because the water content of the sand mass, under ordinary circumstances, will not become too low even after the container has remained dry for several hours. Glazed or varnished pots retain moisture in the sand even longer than porous pots. If one wishes, a simple constant-level device may be used. The temperature during germi-

nation may be readily altered if that is desired. Either the temperature of the air surrounding the cultures may be changed or the pots may be removed from the water and placed in another chamber.

The emerged seedlings may be counted daily or the entire stand may be counted at the end of a given period. Removal of the seedlings as soon as they emerge from the sand does not seem to be necessary with this method in obtaining the maximum germination percentages. Periodical counts made 10 or 20 days after planting would indicate the germinative energy of the seed. Furthermore, in this method, the relative vigor of the seedling is evident from its appearance and rate of growth.

Obviously, the success of this method depends largely upon the capillary action of the sand in taking up water and in keeping the surface of the cultures moist. Different kinds of natural sands vary in the heights to which they will draw and retain moisture when the container is standing in water. By a few simple tests one can easily determine the height of container best adapted to the particular type of sand to be used and to the particular environmental conditions at hand. The sand column should be short enough to remain continually moist but not too wet in the region of the planted seeds. This allows the necessary oxygen to reach the seeds during germination. As to size of the sand particles, we have obtained some of the best germination percentages with sands of approximately the following coarseness: 15 percent retained by the sieve having 20 meshes to the inch, 60 per cent of the particles passing the 20-mesh but retained by the 40-mesh sieve, and 25 percent passing the 40-mesh.

It also is important that the sand contain no fungi which would become parasitic upon the developing seedlings. We have used successfully many kinds of sand without treatment when these were obtained from such sources as deep inland pits or the seashore. Such sand was merely flushed with tap water before planting. However, any sand can be partially sterilized to destroy damping-off fungi by washing in hot water (70° C. or higher). Drenching of the sand with a 1 percent formaldehyde solution and allowing it to stand from 12 to 24 hours will also sufficiently sterilize it for this purpose. The formaldehyde may then be washed out of the sand by flushing thoroughly with tap water and the seeds planted immediately. The sand used for covering the seeds should also be free from fungi.

Among the forest tree species with which we have made germination studies by this method are *Pinus strobus, P. resinosa, P. banksiana, P.*

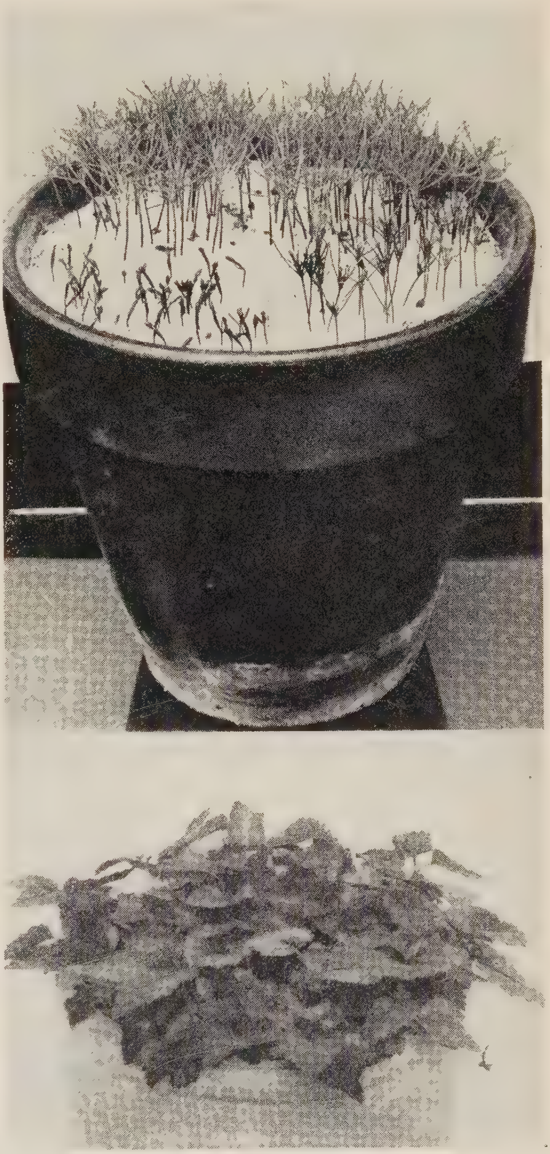

Fig. 1.—Sand cultures used for determining germinative capacity of tree seeds. Above: A 7-inch flower pot divided into 4 sectors, each planted at the same time with 100 seeds. Left front—hemlock: right front —jack pine; rear—2 samples of red pine. No nutrients were applied. Below: Seedlings of gray birch 60 days after planting in sand. In this case a nutrient solution was added at time of planting.

sylvestris, Larix decidua, Pseudotsuga taxifolia, Picea abies, P. glauca, P. rubra, Tsuga canadensis, Acer saccharum, Betula populifolia, Paulownia tomentosa,[1] and *Ulmus americana.* In all these cases, germination percentages have been practically equal to or higher than those obtained at the same time by tests conducted in soil or in an oven germinator. On many occasions, samples of the same seed which became badly molded in the germinator have produced healthy normal seedlings in the sand cultures. At times, some seed samples have given much higher germination percentages in sand than in the germinator.

Addition of nutrient solutions to the sand cultures will provide for larger seedlings, especially in the case of many of the small-seeded broadleaf species. Such feeding is not necessary, however, in order to obtain accurate germination percentages. In case nutrients are applied, containers with waterproof walls should be used since it has been shown (3) that evaporation from the sides of porous containers tends to remove the nutrient salts from the sand mass.

In conclusion, the testing of the germination of slow-germinating seeds in pure sand with continuous sub-irrigation is suggested for trial in view of its simplicity, ease of manipulation, and the favorable results obtained. It seems that such testing by sand culture offers a means of making uniform tests under a wide variety of environmental conditions and at different times. It further appears that this method with its continuously moist sand for the germinating medium approximates natural conditions in the field more closely than many other seed-testing devices.

[1]An introduced tree from Japan that has small, light seeds resembling those of the birch.

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Journal of the South African Forestry Association

A NEW addition to the steadily growing list of forestry periodicals has just appeared, as the Journal of the recently organized South African Forestry Association—also known as Die Suid-Afrikaanse Bosbouvereniging.

The Journal is to be issued twice a year, in April and October. According to the Association's constitution, it "shall be a vehicle for the publication of general articles and research papers on forestry and allied subjects, and for the exchange of views on all matters of interest to members."

Among the more notable papers in the first issue are an interesting historical sketch of the development of forestry in South Africa, a paper on the raising of transplants of several indigenous species, and one on the growth of American southern pines in South African plantations.

The Journal is well printed on a good grade of paper, and is well illustrated. The editor, J. M. Turnbull, is assisted by an editorial committee of four members. The subscription price to nonmembers is six shillings a copy. The address of the Association is P. O. Box 334, Pretoria.—*W. N. Sparhawk.*

THE PHOSPHATE AND POTASH STARVATION OF FOREST SEEDLINGS AS A RESULT OF THE SHALLOW APPLICATION OF ORGANIC MATTER

By S. A. WILDE and R. WITTENKAMP
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Shallow applications of organic matter to nursery soil have always been considered objectionable because such a practice leads to the production of planting stock with superficial root systems consisting entirely of laterals. The present study has indicated even more serious detrimental effects of top dressings. The arresting of the downward extension of the root systems upsets the balance of nutrition as the seedlings are deprived of important nutrients, mainly phosphate and potash, at present at greater depth. Alternate disking and plowing, or rototilling are recommended to prevent this condition.

"The roots are the least known, least understood and the least appreciated part of the plant."
J. E. Weaver.

IN THE early days of silviculture the quality of planting stock was judged according to the size and color of the foliage. In time it was realized that the survival of seedlings in the field depends to a large extent upon the development of the root systems, particularly upon the balance between the crowns and the roots of the planting stock. Thus, a satisfactory toproot ratio became one of the essential requirements of good seedlings. Recently, another important step toward improvement of trees for planting was made by specifying the minimum acceptable diameter of the stem. It is probable that eventually the dimensions of buds, structure of tissue, and development of cell nuclei will also be considered in the evaluation of planting stock.

It is axiomatic that properly developed seedlings can be produced only when the nursery soil contains adequate amounts of all the essential nutrients in available form. A deficiency of available plant nutrients may be due either to an inadequate total supply or to low availability caused by an unsuitable reaction, high fixation, high concentration of soluble salts, inadequate aeration, lack of specific organisms, and other adverse conditions. It has been observed by the writers that organic matter when applied to a nursery soil at an insufficient depth, or as a top dressing, may also seriously upset the balance of nutrition and lead to the production of inferior planting stock. If organic matter, such as peat, is concentrated at the surface, the downward movement of the roots is not favored and the shallow-rooted seedlings are deprived of an opportunity to utilize the nutrients, chiefly phosphate and potash, present in the soil at a greater depth. Potash and phosphate starvation or unbalanced feeding is a common result of this condition.

In a few instances, observed in forest nurseries of the Lake States region, the application of a three inch top dressing of raw peat, slightly worked into the soil, has led to complete deterioration of the pine and spruce seedlings. Aside from these extremes, numerous cases have been noted in which the shallow application of organic remains caused partial starvation of seedlings as manifested by poorly developed, spindly stems, and superficial root systems. The sample plot studies conducted in McNaughton State nursery, Wisc., have indicated that in numerous instances the arresting influence of organic remains may be easily overlooked. As a result of this, the losses of the stock in grading or decreased survival of plantations in the field are often incorrectly attributed to other factors. In order to obtain reliable information on this subject, the field observations were supplemented by a number of pot experiments in the greenhouse.

It was felt desirable first to demonstrate the beneficial influence of adequate amounts of both potassium and phosphorus upon the development of seedlings. This was done by means of a pot culture experiment, carried on with Norway spruce seedlings according to the established methods. The plants grew from seed for a period of six months in half gallon glazed jars filled with quartz sand. The sand was buffered with five percent of acid sedge moss peat and provided with the essential nutrients

including varying amounts of superphosphate and muriate of potash. Twenty-five seeds were planted per jar. The results were convincing and are presented in Table 1 and Figure 1.

A similar technique was employed in the study of the arresting influence of organic matter. The pot culture mediums were prepared from quartz sand, acid peat, hardwood-hemlock duff, and a 7-10-15 fertilizer, the latter applied at a rate equivalent to 325 and 650 pounds per acre. Some of the jars received a top dressing of peat and duff, slightly worked into the soil; seven parts of peat and three parts of duff were used and the rate of application was equivalent to 20 and 40 tons of air-dry organic matter per acre. Six months after planting, the average figures for size and weight of Norway spruce seedlings were obtained. The results, presented in Table 2 and Figure 2, demonstrate the depressing effect of the surface organic matter upon the development of the roots and the stems of seedlings. Of particular interest is the fact that the development of the stem diameter was inversely proportional to the amount of organic matter applied as top dressing.

Because the experiment just described was carried on with relatively young plants, a criticism was offered that with advanced growth and exhaustion of nutrients in the organic layer, the root systems will extend into the lower part of the soil and will utilize the nutrients of the deeper layers. In order to ascertain the validity of this criticism, the experiment was repeated using large two gallon jars, filled with fertile loam soil. A 2-inch top dressing of a half-and-half mixture of peat and hardwood-hemlock duff was slightly worked into the surface. The jars were seeded to different species of conifers and kept in the greenhouse for a period of three years. Because the duff supplied a considerable amount of nutrients, the seedlings developed very luxuriantly and showed no signs of starvation until the beginning of the third year, when growth of the seedlings ceased and the deficiency of nutrients was manifested by the reddish-brown color of the tips of the needles. Examination of the plants at the end of the third growing season showed that no part of the root system extended below the 2½ inch surface layer treated with organic remains, as shown by Figure 3. This experiment indicates that the ability of plants to search for food "as if they had eyes" (Liebig), has certain limitations.

The lateral roots produced by top dressings in the nursery may for several reasons decrease the survival of the seedlings when planted in the field. The respiration and metabolism of plants with superficial root systems may be greatly upset when these superficial roots are placed at a great depth in planting. Also, the bending of such horizontally oriented laterals in the planting hole may easily damage the root collar tissue and thus induce infection of the stock by parasitic fungi.

The tendency of roots to concentrate in the region high in organic matter offers an excellent opportunity to control the length of the root systems. As experience shows, the production of seedlings with root systems of adequate length is achieved when organic remains are

Table 1.—Effect of Varying Amounts of Phosphate and Potash Fertilizers upon the Production of Dry Matter of 6-Month-Old Norway Spruce Seedlings

Number	Pounds per acre applied			Oven-dry weight of an average seedling
	NH_3	P_2O_5	K_2O	*Milligrams*
1	0	0	0	37
2	30	0	0	54
3	30	10	10	82
4	30	20	20	118
5	30	40	40	134
6	30	60	60	197

Fig. 1.—Influence of various amounts of phosphate and potash upon the development of Norway spruce seedlings, grown for 6 months in quartz sand cultures, as follows: 1, No nutrients; 2, nutrient solution including the equivalent of 150 pounds of ammonium sulfate per acre, but no potash or phosphorus; 3, 4, 5, and 6, the same nutrient solution plus the equivalents of 50, 100, 200, and 300 pounds of 0-20-20 fertilizer per acre, respectively.

TABLE 2.—INFLUENCE OF SURFACE ORGANIC MATTER IN POT CULTURES UPON THE GROWTH OF NORWAY SPRUCE SEEDLINGS SIX MONTHS AFTER PLANTING

Number	NPK fertilizer per A.	Surface organic matter per A.	Weight of an average seedling	Length of roots	Length of crowns	Top root ratio	Diameter above root collar
	Pounds	*Tons*	*Milligrams*	*Millimeters*	*Millimeters*		*Millimeters*
1	0	0	25	162	31	.19	.59
2	325	0	146	153	58	.38	1.27
3	650	0	208	141	84	.60	1.64
4	325	20	162	45	77	1.71	1.09
5	325	40	98	57	72	1.26	.88
6	650	20	156	51	81	1.59	1.37
7	650	40	120	62	69	1.01	1.25

thoroughly distributed in the soil to a depth of at least eight inches. Unfortunately, neither spading, disking, harrowing, nor other ordinary methods of soil cultivation distribute the organic matter and mineral fertilizers into the soil to a depth greater than five inches. However, this problem may be solved satisfactorily either by alternate disking and plowing, or by employing recently devised machines of the rototiller type. A brief discussion of both of these methods follows.

The fallowed land, or land supporting green manure crops, is plowed to an approximate depth of nine inches. This exposes comparatively sterile subsoil. About three-fifths of the total application of the shredded peat, duff and commercial fertilizers, or compost, are broadcast over the area and worked into the soil by a thorough disking, to a depth of four or five inches. This fertilized layer is turned under to a depth of eight inches by a second plowing. The remaining organic materials and fertilizers are broadcast, disked, and harrowed.

The rototiller is just finding its use in forest nursery practice, but promises to replace in time the plow, disk, and harrow. In rototilling, the sharp-pointed tines are revolved through the soil by a small motor or tractor. Each sharp point breaks its way through a small amount of soil instead of shearing out large chunks as do the shovel, plow, and disk. This revolving action allows thorough mixing of the organic matter and commercial fertilizers, or compost, to a depth of as much as 10 inches. Simultaneously, rototilling of soil materially contributes to the control of white grubs as well as weeds. The machine of the rototiller type, made according to the specifications of U. S. Forest Service, Region 9, is well suited to nursery practice.

Fig. 2.—Influence of surface applications of organic matter upon the development of Norway spruce seedlings. (1) Quartz sand; (2) 325 lbs. of complete fertilizer; (3) 650 lbs. of complete fertilizer; (4) 650 lbs. of fertilizer plus 20 tons of organic matter applied at the surface; (5) 650 lbs. of fertilizer plus 40 tons of organic matter applied at the surface.

Fig. 3.—Illustration showing concentration of root systems of 3-year-old red pine seedlings due to a top dressing of peat and duff (duplicate results).

TRANSPIRATION OF TREES AND FORESTS[1]

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The author has made a direct study of the transpiration of several important forest trees. It was found that the transpiration in acre-inches of a hypothetical forest ranged from about 5 to 17 for red maple, 1½ to 7 for American elm, and 2 to 8 for northern white pine. Sugar maple and beech each lost about 3 acre-inches. Attention is called to the fact that water requirement data collected on potted seedlings should not be applied to forest trees growing under natural conditions.

CURRENT estimates of the amount of tree and forest transpiration are obtained from both indirect and direct sources. Precipitation, evaporation, and run-off data from well defined watersheds are used as a basis for the indirect estimates. Direct data have been mostly confined to measurements on small potted trees grown under artificial conditions. Many of the current estimates of transpiration are based on data collected in 1879-81 by Franz R. Höhnel (*2*, *3*), who worked with five- and six-year old potted tree seedlings. Recently Minckler (*6*) developed a method suitable for direct measurements of transpiration on large forest trees growing in their natural habitats. The method is based upon sampling the transpiration from a number of representative branches. Data were collected in the summer of 1933 in the vicinity of Syracuse, N. Y., and in 1935 in the Adirondacks near Warrensburg, N. Y. The purpose of this paper is to present a summary of these data and compare them with figures from other sources.

[1]Data are taken from the author's unpublished thesis submitted in partial fulfillment of requirements for the degree of Doctor of Philosophy at the New York State College of Forestry. Work was done under the direction of Dr. Henry F. A. Meier.

Transpiration data were collected from three specimens of red maple (*Acer rubrum* L.), four of American elm (*Ulmus americana* L.), three of northern white pine (*Pinus strobus* L.), and one each of beech (*Fagus grandifolia* Ehrh.) and sugar maple (*Acer saccharum* Marsh.) a total of 12 individual trees. The sugar maple and beech were located in the Adirondacks near Warrensburg, N. Y. The others grew near Syracuse, N. Y. The mean annual rainfall at both Syracuse and Warrensburg is about 40 inches.

A description of the trees is given in Table 1. Columns 5 and 6 of this table show the number of leaves and the total area of ventral leaf surface for each tree. The total number of leaves on each tree was determined by a very careful estimate based on an actual leaf count of the branches tested for water loss.

TABLE 1.—TREE DESCRIPTION AND TRANSPIRATION DATA

1	2	3	4	5	6	7	8
Tree	D.b.h.	Total height	Clear stem length	Estimated leaves per tree	Total area ventral leaf surface	Basis: Observations of transpiration	Seasonal mean transpiration with standard error
	Inches	*Ft.*	*Ft.*	*No.*	*Sq. meters*	*No.*	*grs./sq.meter/hour*
Red maple 1	2.5	15	4	8,000	18.4	19	20.88 ± 2.76
Red maple 2	13.0	53	22	65,000	165.1	27	11.83 ± 1.48
Red maple 3	11.6	65	30	90,000	303.3	23	14.18 ± 1.72
A. elm 1	13.0	37	16	40,000	69.6	18	11.20 ± 1.35
A. elm 2	8.3	30	10	20,000	43.4	18	8.03 ± 1.45
A. elm 3	8.0	52	30	15,000	58.4	8	20.82 ± 4.14
A. elm 4	8.1	30	15	27,000	71.0	16	23.68 ± 3.95
N. white pine 1	7.1	32	9	1,250,000	92.6	19	5.76 ± 0.82
N. white pine 2	10.9	45	20	2,200,000	134.0	16	3.98 ± 0.49
N. white pine 3	12.0	58	30	3,600,000	208.8	17	10.76 ± 1.87
Sugar maple	11.7	70	40	30,000	87.0	30	7.97 ± 0.61
Beech	10.3	75	40	35,000	84.0	42	8.10 ± 0.77

The leaf area of the broadleaved species test branches was determined by tracing them out on paper. The area of the leaves was calculated by a knowledge of the weight per unit area of the paper. It was considerably more difficult to determine the area of the pine needles. After the transpiration data had been obtained, the branch was severed from the tree, the needles counted and their average length determined. A fair sample of the needles was killed, fixed, and sectioned on a freezing microtome. The sections were mounted on glass slides and the width of the sides bearing stomata measured with an eyepiece micrometer. Enough measurements were made to give a reliable mean for the branch. The area of the stomatal bearing (ventral) sides of the needles on a given branch was computed by multiplying the number of needles by their average length, and this product by twice the average width (two sides bear stomata). A correction was also made for the taper of the needles, but this proved to be very small.

Referring again to Table 1, it is noted that the basis for the mean transpiration shown in column 8 is given in column 7. Transpiration measurements were made on different parts of the tree, on different days throughout the summer, and at different times of the day. The results from individual measurements on a given tree varied according to light intensity, relative humidity, time of day and season, and probably position on the tree. Soil moisture of a given tree site did not vary enough throughout the season to affect noticeably transpiration of that tree. The means in column 8 are all signficantly greater than their standard errors, that of American elm No. 3 being least significant. The chances, however, are only 1 in 20 that the true mean lies below 11.03 or above 30.61. The mean for sugar maple is one of the most significant. The chances are only 1 in 20 that the true mean differs from the estimated mean by more than 1.24, assuming, of course, that the method of measurement is accurate. Any bias in this respect is not shown by the standard error.

At the time of each transpiration measurement the light intensity on the experimental branch and the relative humidity at the branch level were recorded. Soil moisture samples were taken each day. Light intensity was measured with a Western photometer and relative humidity calculated from the experimental data (*6*). The individual transpiration measurements were positively correlated with light intensity and atmospheric saturation deficit but will not be discussed in this paper. The figures in columns 12, 13, 14 of Table 1 are season averages of the respective factors for the days upon which measurements were made on a given tree. Column 13 shows that mean relative humidity varied little from tree to tree. In other words, each tree was tested under average humidity conditions for that summer. Column 12 shows the relative exposure of the tested branches and, in so far as they are typical of the tree, indicates the relative exposure of the tree as a whole. Red maple, No. 3, American elm No. 3 and No. 4, and northern white pine No. 3 grew in very moist bottomland. This is shown by the soil moisture figures in column 14. No detailed discussion is given here, but it can be shown that

TABLE 1.—TREE DESCRIPTION AND TRANSPORTATION DATA

9	10	11	12	13	14	15	16	17
Mean transpiration entire tree per day	Transpiration for 150 day season	Average light in open at time of experiment	Average light on tested branch time of experiment	Average relative humidity	Average soil moisture	Trees assumed per acre	Seasonal transpiration	Place and time
Liters	*Liters*	*Percent*	*Percent*	*Percent*	*Percent*	*Number*	*Acre-inches*	
4.62	693	68.0	55.2	45.0	15.4	700	4.72	Syracuse 1933
23.50	3520	65.5	24.0	55.5	12.7	225	7.71	" "
51.70	7770	73.3	28.0	55.3	335.0	225	17.02	" "
8.70	1360	73.3	32.8	51.9	8.6	200	2.65	" "
4.18	628	55.8	37.4	52.0	9.1	250	1.52	" "
14.60	2190	55.5	8.2	53.4	329.0	300	6.39	" "
20.20	3030	70.0	40.4	61.8	241.0	250	7.37	" "
6.42	963	51.0	43.6	49.0	8.6	400	3.75	" "
6.44	967	78.0	20.8	50.0	11.8	250	2.35	" "
26.90	4040	67.0	41.3	52.8	260.0	200	7.87	" "
8.32	1250	67.4	29.2	64.9	39.0	250	3.04	War'sburg 1935
8.17	1225	66.7	27.2	65.8	39.0	250	2.98	" "

the seasonal mean transpiration per unit of leaf area of the trees is correlated with the corresponding mean light intensity and soil moisture. This indicates that, in any restricted area, the total amount of water lost from an individual of a given species depends upon its exposure, the moisture content of the soil, and its leaf area. The humidity conditions of the area will help to determine the level of transpiration for the vegetation as a whole. Other things being equal, all broadleaved species tested had about the same transpiration per unit of leaf area. The pines, under the same conditions, transpired about half as much per unit leaf area as the hardwoods. Their relatively greater leaf area largely compensated for this in total amount of water lost.

Using the data in column 10 as a basis, it is possible to calculate the transpiration of a *hypothetical* forest. Column 16 shows the seasonal transpiration in acre-inches of an approximately fully stocked forest stand made up of an assumed number (column 15) of trees of the type described in the table. Densities corresponding to the stocking figures given are probably somewhat higher than actually exist in most places, but probably are not unattainable. The average forest may easily have enough additional vegetation present to compensate for the lack of trees of this size. It must be remembered, however, that the conditions that would prevail in the hypothetical forests do not necessarily apply to the trees used in the present experiments. It should be emphasized that the amount of foliage and its exposure, the soil moisture, and the humidity level are the important factors in comparing water loss from different forests of the same species. Basal area or density taken alone may be misleading.

One of the most comprehensive studies of tree transpiration by direct methods was made by Horton (*4*). Horton used Höhnel's (*2, 3*) water-requirement data collected from potted seedlings by the loss-of-weight method, and applied them to forest trees by determining the weight of the leaf crop for various trees. Assuming the same number of trees per acre, Horton's transpiration data for white pine are about the same as those found in the present study. The same distinction is not made, however, between individual trees on widely different sites. For example, the seasonal mean transpiration per unit of leaf area for northern white pine No. 3 in the present study is 2.7 times as great as for the number 2 pine. The latter was a sheltered tree situated on a comparatively dry west slope; the former a relatively exposed tree on very moist bottomland (see columns 12 and 14, Table 1). Horton's estimate of water loss by transpiration from a beech forest is about five times as high as estimated in this paper for a comparable forest. It is now recognized (*1*) that transpiration data obtained from potted tree seedlings cannot, with accuracy, be applied to forests. It has been known for some time that water requirement depends largely upon environmental conditions, especially light, relative humidity, and soil moisture. Similarly, transpiration data collected from exposed trees should not be applied, without qualifications, to hypothetical forests of high density. In Table 1, column 15, the number of trees assumed per acre is governed both by the size of the individual experimental tree and by its exposure as shown in columns 2, 5, and 12. This stand density of the hypothetical forest should be regarded as flexible. It may be altered and the acre-inches in column 16 changed accordingly.

Additional data relative to the water consumption of trees and forests based on direct measurements of transpiration are given by Baker (*1*) and Raber (*7*). The latter publication is very comprehensive since it contains much of the available information on this subject. Estimates of water consumption by forests, calculated by the indirect method, have been made by Kittredge (*5*). His figures and estimates for the Stanislaus River drainage in California are as follows: Precipitation 43 inches, run-off 26 inches, interception 6 inches, evaporation 3 inches, with 8 inches accounted for by transpiration. Unpublished data collected by C. R. Hursh, of the Appalachian Forest Experiment Station, in the 70-inch rainfall belt of the southern Appalachians indicate that transpiration plus evaporation is about 26 inches in that region. No allowance was made for deep seepage because the geology of the area did not indicate its occurrence.

Summary

Transpiration experiments were conducted near Syracuse, N. Y., and Warrensburg, N.

Y., under diverse conditions on 12 individual trees, including five species. The total number of leaves and total ventral leaf area was carefully estimated for each tree. Statistically significant seasonal means of transpiration in grams per square meter of ventral leaf surface per hour were obtained. Current transpiration of a particular tree depended upon light intensity, relative humidity, and time of day and season. Because of the difference in light intensity and soil moisture conditions, the seasonal mean transpiration per unit of leaf area for one white pine was 2.7 times greater than for another otherwise comparable one. The data indicate that the species make-up, the amount of foliage and its exposure, the soil moisture, and the humidity level are the important factors in comparing water losses from different forests.

Transpiration in acre-inches of a hypothetical forest was found to range from 4.72 to 17.02 for red maple, 1.52 to 7.37 for American elm, and 2.35 to 7.87 for northern white pine. Sugar maple and beech forests lost 3.04 and 2.98 acre-inches respectively. These figures do not differ widely from others that are available. It is concluded, however, that water-requirement data collected on potted seedlings should not be applied to forest trees growing under natural conditions. Likewise, caution should be used in applying individual tree data to entire forests.

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First Year of Operation of Duke's Graduate Forestry School

DUKE UNIVERSITY'S graduate School of Forestry, which was opened last September culminating seven years of preparation, is experiencing a successful first year of operation. It is the third graduate school of forestry to be established in this country, the others being at Yale and Harvard Universities.

Twenty-one men, from 13 states and four foreign countries and representing 18 institutions, are enrolled in the school. Many of the students are expected to be candidates for the degree of master of forestry at the close of the year because they had already completed undergraduate courses at other forestry schools before coming to Duke. Also, as in previous years, a number of students are enrolled in the Duke graduate school of arts and sciences with forestry as their major.

Last September the school began with a full-time faculty of seven professionally trained foresters, in addition to two instructors in botany from the regular university faculty, and an administrative staff. Dr. Clarence F. Korstian, who has been director of the Duke forest since 1930, is dean of the school.

Present members of the school's faculty, in addition to Dean Korstian, who is professor of silviculture, are: T. S. Coile, assistant professor of forest soils; Dr. Ellwood S. Harrar, associate professor of wood technology; Dr. Paul J. Kramer, associate professor of botany; William Maughan, associate professor of forest management; Francis X. Schumacher, professor of forestry; Roy B. Thomson, associate professor of forest economics; Albert E. Wackerman, professor of forest utilization; and Dr. F. A. Wolf, professor of botany.

Announcement was recently made of the appointment of Dr. James A. Beal, U S. Department of Agriculture entomologist at Fort Collins, Colo., to a professorship of forest entomology in the Duke forestry school. He will undertake his new duties in September.

BRIEFER ARTICLES AND NOTES

First Awards of Fire Medal

The first awards to be made under the American Forest Fire Foundation were approved on March 3, 1939, by the executive board of the foundation. The three cases receiving approval were:

Urban J. Post, Buffalo, Wyo., forest ranger, Bighorn National Forest.

Bert Sullivan, Cody, Wyo., temporary employee of the U. S. Bureau of Public Roads.

Paul E. Tyrrell (posthumous), junior forester, late of Oakland, Calif., and formerly of the Shoshone National Forest.

Of a total of 13 persons recently recommended for the medal and considered by the Board, three were approved, two cases disapproved, and 8 cases held for additional evidence and supporting data and later decision.

The first of the American Forest Fire medals were awarded to Post and posthumously to Tyrrell for heroic action on the tragic Blackwater fire of August 21, 1937, on the Shoshone National Forest, Wyo., during which fifteen men lost their lives—two forest rangers, one junior forester, two C.C.C. foreman and ten C.C.C. enrollees.

These first two forest fire medals were presented at the annual meeting of the American Forestry Association on March 22, 1939, in Washington. That to Sullivan will be presented later in the year, possible in Wyoming.

The medal is of simple and dignified design (Fig. 1), of heavy bronze, 1½ inches in diameter, hung on a red and green ribbon, colors symbolic of fire and the forest, all enclosed in a leather case. With the medal there were also presented a lapel button or rosette of red and green and an engraved citation reciting the heroic act which justified this honor unusual in American forestry circles.

Contributions toward a permanent endowment of an American Forest Fire Foundation to provide, in appropriate cases, recognition in the form of a medal for heroic action in fighting forest fires are coming in slowly. The Board set $3,000 as a minimum for such an endowment; less than two-thirds of this has been contributed to date.

The executive committee or board of the foundation consists of the following men: J. P. Kinney, chairman, American Forestry Association; Tom Gill, Charles Lathrop Pack Forestry Foundation; T. E. Goodyear, Association of State Foresters; John B. Woods, National Lumber Manufacturers Association; and Jno. D. Guthrie, Society of American Foresters.

Jno. D. Guthrie,
American Forest Fire Board.

Fig. 1.—The American forest fire medal.

Watershed Management—More Than Mere Protection

Gradually the term "watershed management" has invaded the field of forestry and today it is taking its place along with well accepted terminology such as forest or range management. Little effort, however, has been made to define "watershed management" simply and adequately and as a consequence many ordinarily well informed foresters confuse "watershed management" with one of its many phases. Frequently the question is being asked, "What is watershed management?" and, at the risk of appearing elemental to some, at least a partial answer is given here.

Watershed management is the practice of handling the resources of a drainage basin to produce maximum yields of usable water. Erosion control and prevention, flood control, stream flow regulation and stabilization, and other similar activities are included in watershed management although each one is only a phase of the broad subject.

Too many people unfortunately have the mistaken idea that watershed management and protection are synonymous. Actually watershed protection is only one phase of management just as protection of the forest from fire, insects, disease, and other destructive forces is only one phase of producing continuous, profitable timber crops through forest management. Control of an eroding gully is similar to control of a small forest fire—both are essential parts of management but obviously neither is management in its entirety. Protection comes with management but management does not result from mere protection.

Watershed management embraces restorative, protective, and improvement practices. The restorative aspects include recognition of land misuse and watershed deterioration; removal or correction of the factors contributing to misuse; and the reestablishment of favorable conditions by either natural or artificial methods. The latter methods include both revegetation and engineering structures. The protective aspects are largely the maintenance of acceptable conditions where these already exist. The improvement aspects include those practices by which *usable* yields of water actually are increased by resource management.

Of all the phases of watershed management, watershed improvement is the most important and yet has received the least attention. Perhaps this is to be expected because only in a few instances has watershed management research progressed far enough to indicate how timber marking rules or grazing methods might possibly be modified to improve water yields. But where water is scarce and valuable, watershed management sooner or later must mean that timber and forage production will be subordinate to water production and, consequently, timber and forage must be harvested in such a way that usable stream flow will be increased.

Complications in the application of watershed management are bound to arise because details pertinent to one watershed may not apply in another. For example, where ample natural or artificial storage is available, the objective may be to manage the vegetation of the watershed so that run-off will be the greatest possible without inducing erosion or floods. On other watersheds where storage is not available natural stream flow regulation must be accomplished by encouraging maximum infiltration of water into the soil, the soil then acting as the storage reservoir. Again, where the major share of the precipitation falls as rain, one system of watershed management may be dictated whereas, if snow provides most of the precipiation, other methods may be more desirable.

Watershed management, therefore, can and must go further than mere coordination of forest and range management. Although good forest management for timber production and good range management for forage production will generally result in protection of watershed values, it does not necessarily follow that the coordination of timber management and range management alone will constitute watershed management. Watershed management—that is, *the production of maximum yields of usable water*—especially on watersheds where water yield is more important than the production of timber or forage, may require changes in what ordinarily would be good forest and range utilization simply to increase water yield As always, multiple use will prevail, but land management primarily for water production and stabilized stream flow is on the way and, unless the foresters responsible for land management accept the full measure of their responsibilities on important water yielding areas, there is little

doubt that before long other groups will be called upon to institute watershed management in its broadest aspect.

Chas. A. Connaughton,
Rocky Mountain Forest and Range Experiment Station.

Extending the Natural Range of Slash Pine in Alabama

Slash pine (*Pinus caribaea* Morelet) is one of the most valuable of the southern pines. It is the most desirable turpentine species, and one of the best for timber production and for pulpwood. The natural range of the slash pine, however, is limited, it extends inland only 60 to 100 miles from the Atlantic and Gulf Coasts. In Alabama the slash pine is found growing naturally only in the extreme southern part of the state (Fig. 1). If its range could be materially extended northward in Alabama, it would afford an opportunity to a large number of woodland owners to realize greater returns from this valuable, rapid growing species.

According to Toumey and Korstian,[1] "The limits of the natural range of a species are largely a matter of its capacity to reproduce. The range of a species can usually be extended by planting, but when so extended, it does not reproduce, and in time the natural range is re-established although the trees may live and grow to fair size."

In order to study the behavior of slash pine outside its natural range the Alabama Agricultural Experiment Station established plantations of the species at Auburn, Ala., in 1927 and in 1932, and at LaFayette and Alexandria, Ala., in 1933. The plantations at Auburn have been in existence for 11 and 6 years; those at LaFayette and Alexandria, for 5 years. Auburn is approximately 60 miles, LaFayette 80 miles, and Alexandria 160 miles north of the natural limits of slash pine.

During the summer of 1937 cones were observed on several of the trees in the plantations at Auburn. Three cones were found in the 11-year-old plantation; two cones were on one tree and, the third on a tree some distance away. Both trees were located on the periphery of the plantings. In the 6-year-old plantation also several trees were found with cones on them. More trees with cones were found in the younger plantation than were found in the older plantation. In most cases the cones were much smaller than normal, but two cones on one of the trees in the 6-year-old plantings appeared to be normal in all respects. As yet no cones have been found in the plantations north of Auburn.

In view of a statement by Mattoon,[2] "The lack of production of viable seeds may be regarded as a probable result of planting slash far above its present home range," these cones were watched with considerable interest. When they ripened they were collected and saved for testing.

The cones were dried, and the seed was extracted and tested for germination. In a cut-

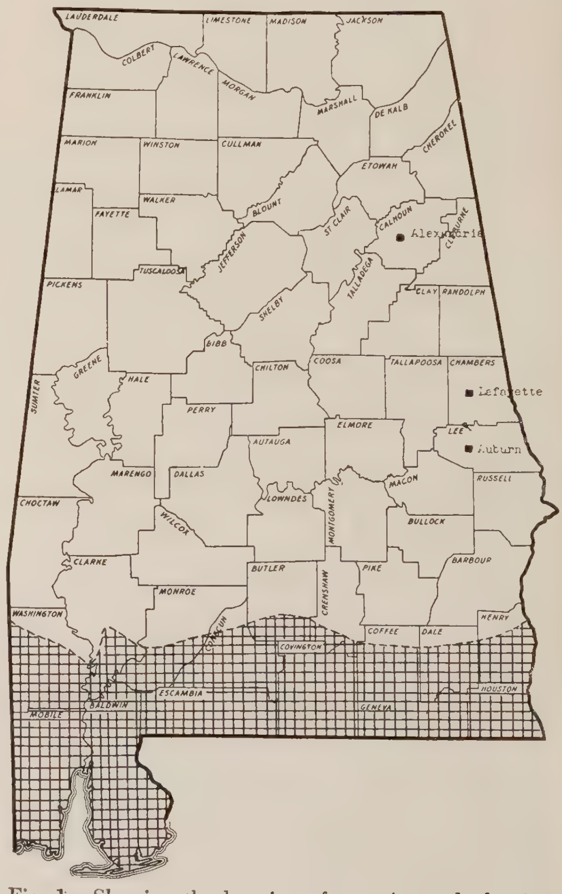

Fig. 1.—Showing the location of experimental plantings and the northern limits of the slash pine in Alabama.

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[1] Toumey, J. W., and C. F. Korstian. Foundations of silviculture upon an ecological basis, 2nd Ed. John Wiley & Sons, Inc., New York. P. 47. 1937.

[2] Mattoon, W. R. Twenty years of slash pine. Jour. Forestry 36:569. 1936.

ting test, 25 percent of the seed from one cone was firm and whitish in color, which indicated that the seed might be viable. The balance of the seed was germinated in sand flats. The results of the germination test are given in Table 1.

Table 1.—Results of Germination Test of Slash Pine Seed Collected at Auburn, Ala.

Source of seed	Number of seeds sown	Number germinated	Germination percent
7-year-old tree, normal cone	45	10	22.2
7-year-old tree, normal cone	50	2	4.0
12-year-old tree, small cone	6	1	16.6

In view of the doubts expressed regarding the ability of the slash pine to produce viable seed north of its natural range these results are interesting. The germination percentages, even though low, indicate that the slash pine can produce viable seed at a considerable distance north of its natural limits.

Even though only two normal cones and a larger number of small ones were found, the fact remains that these young trees did produce viable seed and are thus able to reproduce themselves.

D. J. Weddell,
Ga. Division of Forestry.

Influence of Kiln Temperatures on Field Germination and Tree Percent in Northern White Pine

The Forest Products Laboratory recommended schedule for kiln drying air-dry or precured northern white pine cones in a modern, steam-heated dry kiln with forced-air circulation and automatic temperature control is a constant temperature of 140° F. and a relative humidity of 40 percent. This condition was found to be a safe treatment for northern white pine cones for as long a duration as 12 hours. The maximum yield of seed would ordinarily be expected under these conditions to be obtained after 8 hours of kiln drying. The recommendation is based upon experiments made at the Cass Lake extractory in the fall of 1936.

As the interpretations of the experiments were based upon the laboratory germinative capacity of the 16 seedlots involved in the experiment, it was decided to follow up this measurement of seed viability in the field as a further check on the recommendation. The 16 lots of seed were sown in a 16 by 16 Latin square in the Lydick nursery at Cass Lake, Minn., in the spring of 1937. After the germination was complete a 100 percent count of the seedlings in each of the 256 plots was made. In the fall another complete count was made of the 1-0 plants. The data obtained are given as percentages of the original number of seed sown in columns 5 and 6 of Table 1.

Comparing the field germinative capacity and tree percentage data with the original laboratory germinative capacity data in column 4 of Table 1, we find that the original cone treatment at 140° F. for 12 hours has not resulted in either reduced field germination or tree percentage, and that the original recommendation based on the laboratory germinative capacity is sound.

The mean difference between the laboratory germinative capacity and the field germinative capacity is 16.1 percent, and from column 7 of Table 1 it appears that all the seedlots germinated about the same in the field except possibly the one given the most severe cone treatment, namely 160° F. for a duration of 12 hours, which has a lower percentage of viable seed germinating in the field than the other 15 seed-lots.

In calculating the percentage of viable seed producing 1-0 trees, as given in column 8 of Table 1, we see that the viable seed obtained from cones treated at 160° F. for durations of 8 and 12 hours apparently fails to yield as many 1-0 plants as the other seedlots. As the ratio of field germination to laboratory germination is fairly consistent, the lower tree percentage in these two seedlots must be caused by greater losses of seedlings in these lots than in the other 14 lots during the first year's growth. The losses of seedlings during the first year's growth as a percentage of the original number of seed germinating in the field is given in column 9 of Table 1. The losses in the last two treatments are significantly greater than the losses in the other 14 treatments. Northern white pine seed of the 1936 crop obtained from cones kiln dried at 160° F. for 8 hours or longer, not only had a reduced seed viability, but also produced seedlings that had a higher mortality during the first year's growth.

TABLE 1.—SUMMARY OF LABORATORY AND FIELD TESTING OF NORTHERN WHITE PINE SEED OBTAINED FROM HEAT-TREATED CONES OF THE 1936 SEED CROP

Original cone[1] treatment			Laboratory germinative capacity	Field germinative capacity	Tree[2] percent	Percent of viable seed germinating in field	Percent of viable seed producing trees	Losses[3]
Treatment	Kiln temperature	Duration of treatment						
No.	*°F.*	*Hours*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1	100	2	94.1	76.7	58.0	81.5	61.6	25.0
2	100	4	93.1	70.8[4]	50.5	76.1	54.2	29.1
3	100	8	93.3	73.8	54.5	79.1	58.4	26.3
4	100	12	90.1	77.3	60.7	85.8	67.4	21.9
5	120	2	94.6	75.8	52.9	80.1	55.9	30.2
6	120	4	96.8	79.1	59.1	81.7	61.0	25.5
7	120	8	92.6	76.6	57.9	82.7	62.5	24.5
8	120	12	92.9	75.1	51.6	80.9	55.6	31.9
9	140	2	94.6	78.7	57.8	83.2	61.1	26.8
10	140	4	93.1	76.1	59.6	81.7	64.1	21.9
11	140	8	91.9	75.8	55.0	82.5	59.9	27.6
12	140	12	93.0	77.1	60.7	82.9	65.3	21.8
13	160	2	79.0[4]	64.2[4]	46.3[4]	81.3	58.6	28.1
14	160	4	69.9[4]	54.0[4]	38.4[4]	77.3	55.0	30.6
15	160	8	45.4[4]	35.9[4]	22.2[4]	79.1	48.9	38.8[4]
16	160	12	34.7[4]	25.0[4]	13.8[4]	72.1	39.8	45.5[4]

[1]All kiln treatments were made at a 6 percent wood equilibrium-moisture-content condition.
[2]Tree percent is defined as the percent of the number of seed sown developing into utilizable 1-year seedlings. As the seedlings were not graded the term is here used to mean the total number of 1-year seedlings.
[3]Losses are calculated as a percentage of the number of seed germinated in the field.
[4]Significantly different at P = 1 percent.

It is therefore apparent that seed injuries resulting from excessive heating during the extraction process are likely to be much greater than would be inferred from germination records obtained in the laboratory or field. It is reasonable to suppose that very important losses in first-year seedbeds may have occurred when seed extracted with uncontrolled temperature was used.

RAYMOND C. RIETZ,
Forest Products Laboratory.

A METHOD OF ESTIMATING AREA IN IRREGULARLY SHAPED AND BROKEN FIGURES

Where extreme accuracy is not essential or the time required by planimetering not justified or for some reason it is not practicable to use a planimeter, one method of estimating the area in irregularly shaped and broken figures is to rule a piece of tracing paper into small squares of known size and count the number of squares covered by the area to be measured.

This procedure was followed in detection planning studies at the Appalachian Forest Experiment Station, where it was necessary to determine the total area directly visible to numerous potential lookout points as shown on visible area maps. Instead of squares, the counting unit was a rectangle equal to 1/100 of a rectangle spanning one minute of latitude and one minute of longitude. Each of the tiny rectangles, therefore, represent approximately 6.95 acres. Continued counting of these rectangles was quite exacting and it was thought that an equally accurate and faster method might be devised.

Accordingly, a second overlay of one minute latitude by one minute longitude, was drawn up on which were placed 25 dots. Each dot was spaced at the center of an imaginary rectangle equal to four of the small rectangles used in the previous system and therefore represented a ground area of about 27.80 acres. An overlay grid covering the whole map and ruled into one minute rectangles enabled the worker to systematically follow through an entire map, counting each visible area once and only once.

Three visible area maps were selected representing types of maps commonly encountered, viz., visible areas in large and few, well-grouped bodies; visible area in small and scattered

pieces; visible areas intermediate in size and somewhat scattered. Five men estimated the total amount of visible area on each of these maps by the two methods of counting rectangles and counting dots. The order in which men received the different maps was not systematic; when a man received a map he flipped a coin to determine which method he was to use first. Table 1 presents the deviations of each man's estimates from the measured area (as determined by planimeter) in percentage of the planimetered area.

The ratio of the mean difference between the two counting methods (2.66) and its standard error (0.605) is found to be 4.396. Since a ratio of this size in a sample of 15 differences would occur only once in about 1000 times by chance the conclusion is justified that the dot method used was superior. The results were particularly encouraging because dots were spaced only one-fourth as intensively as rectangles. Also, since the dot method required only two-thirds as much time as the other method and apparently lessened eye strain, it claimed a number of distinct advantages. The dot principle should be adaptable to other kinds of area determination problems.

Table 1.—Errors in Estimated Total Visible Area, Expressed in Percent of Planimetered Area, with Different Men Applying "Dots" and "Rectangles" Methods to Selected Visible Area Maps

	Method: Dots	Method: Rectangles	Difference between methods
	Percent error	Percent error	Percent error
Map 1. Visible areas large, grouped			
Man A	1.84	2.45	0.61
" B	1.02	4.40	3.38
" C	2.25	5.11	2.86
" D	0.51	6.54	6.03
" E	2.25	0.61	—1.64
Map 2. Visible areas small, scattered			
Man A	2.09	5.46	3.37
" B	2.46	9.45	6.99
" C	2.95	4.54	1.59
" D	5.71	10.01	4.30
" E	0.86	3.74	2.88
Map 3. Visible areas intermediate, somewhat scattered			
Man A	0.41	2.81	2.40
" B	1.17	6.31	5.14
" C	1.24	1.99	0.75
" D	2.47	2.40	—0.07
" E	0.41	1.72	1.31
Sum	27.64	67.54	39.90
Mean	1.84	4.50	2.66

These tests were conducted while the writer was a member of the staff of the Appalachian Forest Experiment Station. The experiment was made possible by the participation of George M. Jemison, George M. Byram, Robert M. Beeman, and Brooke Davis.

C. A. Abell,
California Forest and Range Experiment Station.

Frost Damage to Forests in Northern New Jersey

Recent observations of widespread frost injury to forest vegetation in northern New Jersey indicate that late spring frosts may be a factor influencing the composition of forest stands. The injury was particularly severe in the valley bottom between Beech Glen and Rockaway Valley in Denville Township. The forest in this region occurs in a zone of transition from the oak-hickory type to the northern hardwood type, with the oak-hickory predominating. The stands are second-growth and vary in size from sapling to pole.

The species seriously affected by frost included the oaks, white ash, black locust, sycamore, tulip poplar, and hickory. The leaves of these species were completely killed, as were the more succulent shoots of white ash. Species not affected included black cherry, sugar maple, large-tooth aspen, yellow birch, American elm, basswood, and beech.

Records of minimum temperature and frost obtained from the U. S. Weather Bureau for the stations nearest to the Rockaway Valley were reported as follows:

	1938 May 13	1938 May 14
Charlotteburg, N. J.	28°F. Killing frost	26°F. Killing frost
Dover, N. J.	32°F. Heavy frost	33°F. Heavy frost
Boonton, N. J.	33°F. No record	32°F. No record

While these temperatures were not recorded in the immediate vicinity of the area in which greatest injury was observed, they indicate that in general the temperature was not so low as might be inferred from such severity of injury; lateness of the season was apparently of more

importance. The depth of the frost layers was unusual, as evidenced by the fact that all the leaves of a large white oak tree, estimated to be about 70 feet in height, were completely killed. Higher on the valleysides, however, injury was scattered and in general was less severe. This is in line with the results of a study of spring frosts in Britain, where it was shown that "topography, by checking or promoting the flow of cold air, plays an important part in regard to frost intensity."[1]

A comparison of the species affected with those not affected is of practical interest and stimulates consideration of hardiness of the various species within their ecological range. Those not affected are typical northern hardwoods, while those affected include species occurring somewhat north of their optimum range, and therefore more susceptible to injury from an extreme condition.

The extent to which anatomical characteristics affect hardiness to frost is imperfectly known, so that no measure can be made of the significance of the fact that the majority of the species affected are ring-porous, while the majority of those not affected are diffuse-porous. It has been shown by Lodewick,[2] however, that sclerosis of parenchyma and crushing of sieve tubes do not take place in species with bast fibres (present in the oaks, white ash, and tulip poplar; absent in sugar maple, yellow birch, and American elm) within the phloem until isolated by periderm. He also points out that the production of lignified cells in the phloem of diffuse-porous species may occur any time after the first surge of the xylem increment, while in the ring-porous species the production of thick-wall phloem elements, bast fibres, and stone cells is coincident with the differentiation of the first summer wood vessels in the xylem. Present lack of information on species physiology makes it impossible to say whether this delay in the lignification of the phloem cells in ring-porous species affects hardiness to late spring frosts, and whether a corresponding effect is present in the leaf structure.

Whatever the mechanics of injury, it seems that stand improvement and planting plans in the low-lying frost pockets, or at altitudes where late killing spring frosts occur, in the transition zone, should consider the susceptibility of the various species to frost damage.

Clement Mesavage,
Allegheny Forest Experiment Station.[3]

Growth and Development of Adirondack Stands

During the summer of 1938, five one-acre permanent sample plots on Finch, Pruyn & Company's land in the Adirondacks were remeasured by Crawshaw of the company, Marinus Westveld, of the U. S. Forest Service, A. B. Recknagel, of Cornell University, and Robert VanOrder, a graduate of Cornell. Of these five plots, one was established in 1918, the other four in 1923. Remeasurements have been accurately made every five years following establishment, and they are becoming increasingly valuable as indicating the trend of development of stands under careful management.

The plots bear out the commonly observed wave like development of softwood stands. Following the cutting of the original stand, there is a temporary set-back. Then the growth of spruce and balsam, particularly the latter, markedly increases. If this continues too long, i. e., until the overmaturity of the balsam causes windfall thereof, there is a period of volume loss, following which there is a second crescendo, with spruce in the ascendency. This goes on until the climax type is reached, when, if no cutting is done, complete stagnation ensues.

On hardwood land the cutting of spruce and fir leaves the big hardwoods in complete ascendency. Only as they gradually die, do the softwoods return, chiefly by means of new trees since the existing trees are generally suppressed by the overarching crowns of the dominant hardwoods.

These five plots are due for a remeasurement in 1943 when these observations on growth and development of Adirondack stands should be further amplified.

A. B. Recknagel,
Cornell University.

[1](Gt. Brit.) Forestry Comm. Bull. 18 (1937). Abstracted from U. S. Dept. Agric. Exp. Sta. Record, Jan. 1938. Page 11.

[2]Lodewick, J. E. Seasonal activity of the cambium in some northeastern trees. New York State Coll. of Forestry. Tech. Bull. 23.

[3]Maintained at Philadelphia, Pa., in cooperation with the University of Pennsylvania.

A Permanent Sample Plot Technique Adapted to Commercial Timber Stands

A simplified yet fairly intensive technique for the establishment of sample plots has been suggested by Henry I. Baldwin[1] of the New Hampshire Forestry and Recreation Department. The method is advocated particularly for growth, mortality, and stocking determination. Briefly, the proposal consists of a strip survey in which the tally is taken separately by 100-foot rectangular sections of the strip as the crew progresses through the area being sampled.

The Division of State and Private Forestry of Region Nine has gradually developed a circular plot tally sheet which has all of the advantages of Mr. Baldwin's rectangular plot samples, and other benefits in addition. Explanations for taking the tally on the form are given almost completely on the tally sheet itself (Fig. 1).

As in the Baldwin plan, plots are representatively established from some known corner or base line. A substantial northern white cedar stake is driven into the ground for the plot center. A plot tape 52.7 feet long is tied to a nail driven into the center of the top of the stake. The tape may be enameled yellow to increase its visibility.

A two-man crew is used to collect the data, though the work can be done by one man in a manner more satisfactory than is possible on a rectangular type of plot.

The tally taker orients the traverse board on which the circular tally sheet is held over the stake and clamps the board in the same position until the plot is completely tallied. The board is supported on a light tripod.

The first tree measured is the first encountered to the east of the true north point within the radius of the one-fifth acre circle. It is bark blazed and marked with lumber crayon when measured, to facilitate later determination of the starting point. The man making the measurements works around the plot from true north moving always in a clockwise direction and taking the trees consecutively. He measures the trees at d.b.h. in inches and tenths with a diameter tape, using a $4\frac{1}{2}$-foot yellow painted pole placed against the tree on the side facing the plot center. The use of this pole insures that the diameter measurement will always be made at the same point. Log lengths, total heights, total used lengths of trees, and even log grades may be given if desired, but our general practice has been to take the diameter measurements only and apply local volume tables based on average used lengths by diameter class.

The measurements are called to the tally man who plats the approximate position of the trees on the form, records the d.b.h. and species thereon using the proper symbols as given on the tally sheet legend, and numbers the trees consecutively on the form. He insures, by sighting over the sheet lines, that no trees are missed and that the consecutive order is preserved. Exact measurement of the position of each tree by bearing and distance is not necessary although it may be desired in more intensive work.

Ten plots per day were measured on a project covering 1,320 acres, or 165 fifth-acre plots established in a northern Michigan selectively cut hardwood forest. The work which was done in May included the tally of all trees 5 inches and larger in diameter. Log grades of commercial trees were also estimated and tallied on each plot.

The refinement of painting numbers on the trees on each plot has never seemed necessary due to the consecutive tally plan based on tree position. No occasion has yet occurred where it would seem difficult in the future to identify and compare identical trees.

Advantages of the circular plot tally sheet and method of sample plot establishment may be briefly summed up as follows:

1. It is the most simple and convenient system of which the division has any knowledge. It is especially adapted to a one-man crew.

2. The relative position of the trees are shown on the tally sheet. Rates of diameter increase may be directly correlated with distance between trees.

3. Future measurements on identical trees are assured without paint marking the trees in the first tally.

4. The method is economical in time; requires only one permanent center post and no chainage notes.

5. It permits a statistical check of the data

[1]Baldwin, H. I. A strip survey adapted to permanent sample plots. Jour. Forestry 36:41-43. 1938.

which are flexible by plots and by individual trees.

6. It is one of the most truly representative methods of sampling, if the plots are randomly placed and dispersed adequately over the area being studied.

7. Errors made in the measurements when establishing the plots may be discovered and corrected in subsequent measurements without destroying the value of the complete data.

8. The plots have a minimum of border, and few line trees occur.

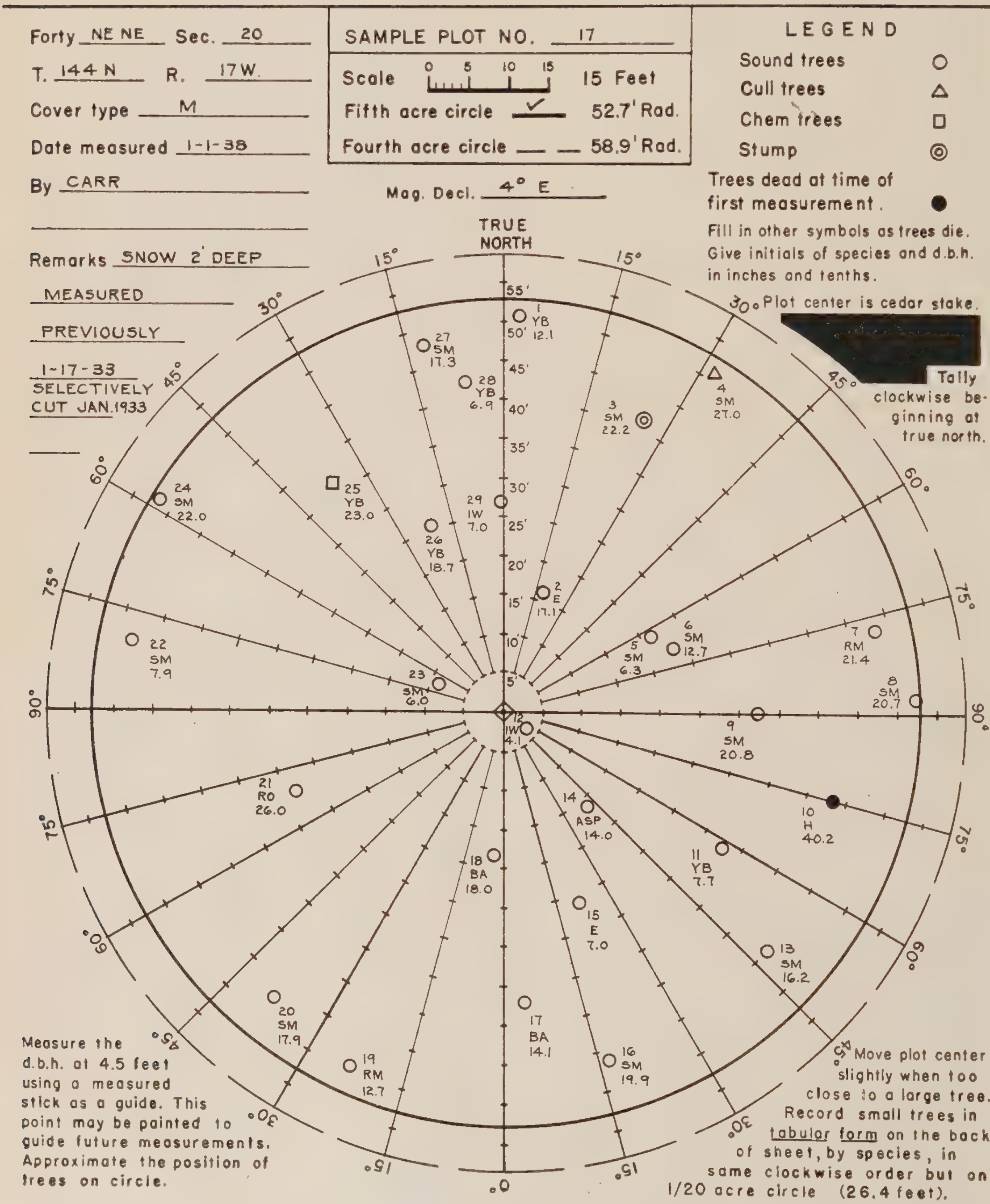

Fig. 1.—Growth measurement tally sheet.

Disadvantages include the presence of occasional large trees near the center of the plot which effectively block off the vision from the plot center to the outer edge of the circle. Plots supporting several hundred trees of small cordwood size are too dense for practical platting on the circular tally sheet, but the form has been found satisfactory in jack pine pole stands containing as high as 60 trees per plot or 300 per acre.

Its simplicity and convenience, and the assurance of future measurements on identical trees and on the same area, make the method one especially valuable to foresters in private employment who are practicing selective cutting and wish to determine and compare the conditions of their stands before and after logging. The form seems deserving of consideration in any plan for the standardization of sample-plot procedure except work in which extreme intensity of record is essential. The method, however, does not preclude this type of intensive work if it is needed.

C. B. Stott and E. J. Ryan,
Division of State and Private Forestry, U. S. Forest Service.

Diameter Class Gauges for Small Stems[1]

Stems and branches not exceeding one inch in thickness can be rapidly measured with estimation to tenth-inch diameter classes using the diameter class gauge shown in Figure 1, B. For seedlings and transplants not exceeding one-half inch in thickness, the diameter class gauge shown in Figure 1, A is effective for measurement to twentieth-inch diameter classes.

Diameter class gauges may be improvised from a piece of stout celluloid secured to a rigid wooden back and handle. From a basal straight edged cut, a series of fixed calipers are cut out as parallel steps at perpendicular distances equal to the diameter class limits. The resultant slots are of sufficient length to accommodate stems of irregular shape. On the tenth-inch gauge (Figure 1, B) the slot at *10* is 1.05 inches wide, that at *9* is 0.95 inches, at *1* it is 0.15 inches, and beyond is an 0.05 slot to accommodate the zero class. On the twentieth-inch gauge (Figure 1, A) the slots are graduated at half these widths.

To measure with the diameter class gauge, it is advanced with the long straight edge bearing on the stem as far as it will seat the stem without wedging. The number of the smallest slot accommodating the stem is its mid-diameter-class value.

These diameter class gauges were developed from the principle illustrated in "gauge for measuring diameters," Figure 2 of a paper by Ferguson.[2] The length of slots necessary in this type of gauge renders design for larger diameters or for more diameter classes increasingly impractical. Diameter class gauges for measurement of diameters of one inch or less, through a range of up to ten classes, with intervals of one millimeter (about 1/25 inch) or more prove very efficient. A half-inch capacity gauge with sixteenth-inch instead of twentieth-inch classes may be preferable for some purposes. Instruments for closer single measurement of small diameters through a larger range have been described by Cummings.[3]

W. H. Cummings,
Central States Forest Experiment Station.

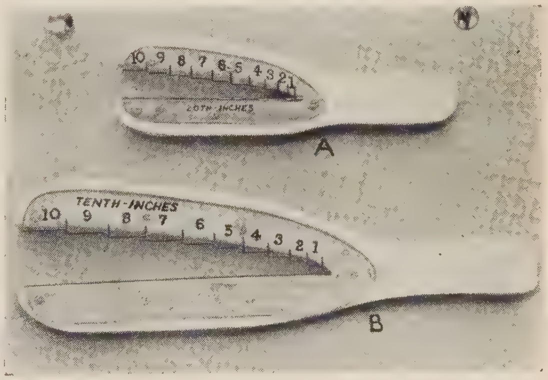

Fig. 1.—*A.* Twentieth-inch diameter class gauge. *B.* Tenth-inch diameter class gauge.

[1]Anyone interested in procuring gauges of the described construction may communicate with the author. Gauges calibrated for desired diameter classes can be furnished for use by foresters at actual cost of construction.

[2]Ferguson, J. H. A. De boomvork voor het meten van kleine diameters. (The tree-fork, a simple instrument to measure small diameters.) Tectona 27: 493-499. 1934.

[3]Cummings, W. H. Tree-fork and steel tape for close measurement of small diameters. Jour. Forestry 35: 654-660. 1937.

REVIEWS

A Guide to Forestry Activities in North Carolina, South Carolina, and Tennessee. William Maughan, editor-in-chief. *287 pp. Illus. Published by the Appalachian Section, Society of American Foresters. 1939. Obtainable from Society of American Foresters, Washington, D. C. Paper cover, $1.50; cloth cover, $2.25.*

During recent years numerous new forestry and conservation agencies have come into existence in all parts of the United States, while some older agencies have greatly extended their activities. So great and so rapid has been the expansion that it has been difficult for foresters to keep informed about conditions in the state or region where they are working. With this situation obtaining in the territory comprising the Appalachian Section of the Society of American Foresters, the Section members with characteristic energy did something about it. A committee of which William Maughan served as chairman compiled complete records of all forestry activities within North Carolina, South Carolina, and Tennessee. This guide book is the product of the committee's efforts.

Descriptions of the various forestry activities have been arranged on a functional basis and listed under the agencies in charge. The subject matter is presented under eight principal chapter headings and includes all the forestry activities of the U. S. Department of Agriculture, the U. S. Department of the Interior, independent federal agencies such as the Civilian Conservation Corps and the Tennessee Valley Authority, the state forestry organizations, farm forestry extension, forestry at educational institutions, forestry societies, and forestry by private interests. Aerial photographic surveys are discussed in an additional chapter. The book concludes with a carefully selected bibliography of 21 pages.

What gives the volume unusual value and interest is the method of presentation. The report on each agency is introduced by a brief history, a statement of its objectives, an explanation of its policies, and a detailed description of each unit where forestry work is being done. For example 22 pages, including two maps and an organization chart, are devoted to the state forestry work in South Carolina. No single phase of the state's forestry effort is passed by; a list of personnel is even included.

Among the most interesting chapters is the one on private forestry. It is broken down into four sections—estate forestry including the Biltmore plantations and the work of the Log Cabin Association; the Farmers Federation, a farmers' cooperative operating in the mountains of western North Carolina; the forestry program of the Seaboard Airline Railway and the Southern Railroad demonstration forest; and the part being played in southern forestry by the pulpwood industry in which the activities of ten companies are listed.

More than a year was spent by the editor and his committee in compiling the material in the volume. Its authenticity is guaranteed because the report on each activity was approved by the agency in charge. It is a splendid publication—comprehensive, authoritative, carefully arranged, and well written. Numerous maps and organization charts are included to assist the reader. It is a book which can be followed in the field, read by the fireside, or used as a reference.

It would be a mistake to let any reader of this review under the impression that the book will be of use only to the forester working in the Appalachian Section territory; on the contrary it should be of value to foresters everywhere who have an intelligent interest in the profession at large. It is especially recommended to other Sections of the Society as a guide for similar publications covering their regions.

Henry E. Clepper.

Statistical Tables for Biological, Agricultural, and Medical Research. By R. A. Fisher and F. Yates. *viii + 90 pp. Oliver and Boyd, London and Edinburgh. 1938. Price 12s 6d.*

This publication brings together under one cover all the tables necessary for the application of the modern statistical theory and practice outlined by the two previous contributions of Fisher, *Statistical Methods for Research Workers* and *The Design of Experiments*, and that of Yates, *The Design and Analysis of Factorial Experiments*. In so doing it supplies a long-felt need of research workers who are using these methods in the solution of their problems. The authors' wide experience in practical research has made it possible for this selection to be particularly adequate. The excellency of the format of the book deserves special mention. Here is stored, easily accessible for reference, a wealth of information on statistical theory, while the constant user of the tables will be insured the minimum of eye strain and fatigue.

The introduction, covering about one-fourth of the book, presents an excellent discussion of the theory and use of tables which either appear for the first time or might seem difficult to use effectively. Use of all the tables is illustrated with well-chosen examples from actual experimental work. Adequate references are given to supplementary material. Indeed, this section of the book might very well serve as a course of study to increase one's skill and resourcefulness in the handling of statistical material.

The 34 tables comprising the main part naturally fall into series or groups. Those in the first group, based on the normal distribution, appeared earlier in Fisher's *Statistical Methods for Research Workers*, and are in constant use in making tests for significance. A number of enlargements here which increase their usefulness may be noted: the t-distribution is expanded from $n = 30$ to include values for $n = 40$, 60, and 120; the variance ratios corresponding to the values of z for different values of the variables n_1, n_2, and P appear along with the distribution of z (this will be welcomed by those accustomed to using the ratio table), 20 percent and 0.1 percent levels for P are added to the original .05 and .01 levels; the table for correlation coefficients has been expanded to include the level of $P = .001$.

The question might be raised as to why the values corresponding to the four levels of significance for each pair of n_1 and n_2 of the z distribution do not appear together. There would seem to be an advantage for such an arrangement in that it facilitates the study of the rate or degree of convergence associated with each pair of n's.

The table for testing the significance for *2 x 2* contingency tables allows for greater precision than the usual x^2 test. It gives 2.5 percent and 0.5 percent points of x_c (square root of x^2 corrected for continuity) for each tail separately. With the smallest expectation, less than 100, and with only one degree of freedom (as in the *2 x 2* contingency table) the asymmetry becomes marked and the deviations of a given magnitude in one direction are less probable than those in the other.

A valuable section to many in forest research should be that on "The Probit and Angular Transformation" (Tables IX to XIV). Here is found a comprehensive treatment of the subject of transformations. Probits are defined and the advantage of their use demonstrated. The reasons for transforming certain types of data before attempting analyses are given, and the various suitable transformations are described and adequately illustrated.

The five tables on factorial designs and the summary of existing information on this timely subject as set forth in the introduction will be of special interest to those experimenters who are already aware of the possibilities for eliminating errors due to heterogeneity in the modern types of experimental design, but who feel handicapped in their use because of limited knowledge and experience. The table on the simple Latin square gives sufficient information for selecting for experimental purposes Latin squares of all sizes to 12 x 12. Simple, clear-cut rules are set down for random selection of such squares. Starting with the simple enumeration of the standard 4 x 4 Latin squares the reader is skillfully led through the labyrinth of enumerating the larger squares which arises from the multiple possibilities with larger numbers.

An outgrowth of the development of factorial designs to care for increasing numbers of combinations are the *balanced incomplete blocks*

for testing large numbers of varieties (or treatments) in which every two varieties occur together in the same number of blocks, so that all comparisons are of equal precision. With a large number of varieties arrangements satisfying this required condition will mean a large number of replications. Explorations of arrangements involving fewer replicates are set forth in three tables. The first of these gives the known combinational solutions involving numbers of varieties (v), experimental unit (k), number of replicates (r), number of blocks (b), and number of blocks in which every two varieties occur together (λ). The other two are indexes of possible designs requiring ten or less replications. The discussion of general principles involved in this subject fittingly illustrates Professor Fisher's outstanding characteristic of giving a subject exact, comprehensive, and intelligible treatment with the greatest economy of words. The story, covering an unbelievably small space, is complete in every detail, even to an elaborate example showing all steps of the analysis.

Investigations of changes in a measurable variable Y where equally weighted observations occur at equal intervals of the independent variable X, e.g. the variations in annual tree ring width, have been successfully handled by use of the curved regression line of the type $Y = a + bx + cx^2 + \ldots$ Those applying this technique will be gratified to find a scheme here which further reduces the arithmetical labor from the already simplified one in Fisher's *Statistical Methods*. The steps in this short-cut method are described in the introduction to Table XXIII, "Orthogonal Polynomials." These coefficients enable one to fit regression equations as high as the fifth degree and with n_1, the number of independent readings, as large as 52. The coefficients of the alternative equation for Y, the sums of squares for the corresponding analysis of variance, the estimated standard error of each coefficient, and individual values of Y may be readily calculated. Hence the curve may be definitely determined and the usual tests of fit applied. If desirable, this equation can be converted into the one in X. This method is so easy to master that it will probably lead to wider use of orthogonal polynomials where applicable.

Other standard functions ordinarily used by the statistician—logarithmic, trigonometric, reciprocals, factorials, squares, square roots, and a collection of constants and conversion factors, covering a wide scope of possible needs—are all in this book. A useful table rarely found elsewhere is that of natural logarithms.

The introduction describes appropriate interpolation methods for the various tables. A method is given for supplementing the linear interpolate where straightforward linear interpolation is inadequate.

A new set of random numbers completes this comprehensive handbook. The method followed in their construction, tests of their randomness, and examples of their use are also included.

BESSE B. DAY,
U. S. Forest Service.

African Pencil Cedar. Studies of the Properties of Juniperus procera (Hochst.) with Particular Reference to the Adaptation of the Timber to the Requirements of the Pencil Trade. *Dept. Sci. and Indust. Research. Forest Prod. Research Rec. 24. 9 pp. 2 pl., 1 fig. 1938. (British Library of Information, New York. 20 cents.)*

Machines for measuring the energy required to make a standard cut showed untreated African cedar pencil slats to be 15 to 22 percent harder to whittle than the best American slats. Means of softening the African cedar were sought. It was found that superheated steam at 150° C. or saturated steam at 10 to 40 pounds' pressure softened the wood without darkening it to an objectionable degree. However, it still cut somewhat less smoothly than American cedar. Further improvement resulted from impregnating the wood with a 5 percent emulsion of rapeseed oil. Eighty-five percent of the African cedar examined had compression wood as compared with 37.5 percent in American cedar. This is believed to be the chief reason why the latter warps less. However, it is not economically practical to eliminate all compression wood. The importance of proper conditioning is stressed, and it is suggested that the field of moisture-proof coatings be explored.

E. M. DAVIS,
U. S. Forest Products Laboratory.

Machinery and Equipment Used for Bending Wood. By W. C. Stevens. *Dept. Sci. and Indust. Research. Forest Prod. Research Rec. 25. 13 pp. 2 pl., 6 fig. 1938.* (*British Library of Information, New York. 20 cents.*)

Wood bending doubtless originated with primitive peoples, and with a few exceptions has continued until comparatively recent years to be done in a primitive and empirical way. Studies began during the World War by the U. S. Forest Products Laboratory resulted in setting forth the scientific principles of mechanical manipulation during bending but were discontinued before practical applications of these principles had been fully developed and methods of preparing wood for bending and its post-bending manipulation had been thoroughly explored. More recently outstanding research in this field has been done at the Forest Products Research Laboratories of England by W. C. Stevens, author of the present pamphlet and of at least two other official publications (Forest Products Research Records, No. 10 *The Practice of Wood Bending* and Forest Products Research Bulletin No. 17 *Methods of Bending Wood by Hand*) as well as numerous articles in the British trade press.

The present pamphlet describes two types of power operated bending machines: the lever arm type and the revolving form type. The principles of their design and operation are clearly presented and some data on requirements for strength of parts and power are given. Application of the second type to bends of 360° or more, such as chair seat rims, and to reverse bends, such as those at the lower end of a fork, spade, or shovel handle, are illustrated. The hydraulically operated hot press so widely used in this country for bending such parts as back posts of chairs is not discussed. Such machines are probably little used in Great Britain.

Under "Hot Form Bending" the statement is made that plywood sheets formed in the straight may be bent and set to shape by the application of heat alone. A revolving gas-heated machine for this purpose is illustrated. Unfortunately, no data are presented on the limitations of this method with respect to ratio of radius of curvature to thickness of plywood.

In a final paragraph Stevens calls attention to the possibilities in bending wood across as distinct from along the grain and suggests this procedure for making the cores for curved doors and the like.

Machinery and Equipment Used for Bending Wood and Stevens' other publications cited above merit careful study by chair and furniture manufacturers. Observance of the principles set forth in these and in publications by the U. S. Forest Products Laboratory would greatly reduce losses in bending wood.

T. R. C. Wilson,
U. S. Forest Products Laboratory.

Gurjun, Apitong, Keruing, Kapur, and Allied Timbers. By S. H. Clarke. *Dept. Sci. and Indust. Research. Forest Prod. Research Rec. 16 (Timber Ser. No. 5). 11 pp. 1 pl., map. 1937.* (*British Library of Information, New York. 20 cents.*)

The timbers described belong to the Dipterocarp family, which is the most important group of commercial timbers in the West-Pacific Tropics. They grow in parts of Burma, the Malay Peninsula, Sumatra, Borneo, and the Philippine Islands. Because they are highly variable in density and other properties they are divided into three classes, the softer and lighter ones belonging mostly to the genus *Shorea*, those of medium weight and hardness to *Dipterocarpus* and *Dryobalanops*, and the heaviest and hardest to *Shorea*, *Hopea*, *Vatica*, and *Balanocarpus*.

Certain structural characteristics useful in identifying the different genera or groups are given, although a "key" to all the species described is not included. Several *Dipterocarpus* species exude fluid oleoresin from freshly cut surfaces, which renders sawing difficult and is objectionable for some uses. In other genera the resin is hardened and does not exude. This matter is being studied by the Forest Department of the Federated Malay States. "Brittle heart," a brashy core at the center of logs due to numerous natural compression failures, is common, especially in the larger overmature trees. The important species are described by country of origin under generic headings. Both trade and scientific names are given.

Arthur Koehler,
U. S. Forest Products Laboratory.

Stave Volume and Defect in Old-Growth White Oak. By Richard D. Stevens. *Arkansas Agric. Exp. Sta. Bull. 362. 26 pp. 8 fig. 1938.*

Foresters, landowners, and timber cruisers concerned with white oak utilization will be interested in this bulletin which presents local volume tables for bourbon and beer staves, based upon data collected in conjunction with two stave operations on the Ozark National Forest. Employing usual volume table construction procedure, Stevens developed local stave tables, based on the Scribner decimal C rule. Their accuracy was tested on 2,246 trees, which were later cut for beer staves. The resulting error was 1.5 percent.

Due consideration is given to cull arising from rot, water soak, pinworm, blowstreak, heart check, and other defects which influence utilization in this highly specialized industry.

The bulletin is a valuable addition to the list of volume tables based on specialized utilization. Accurate tables of this type are needed in managing and appraising timber.

M. H. Bruner,
Clemson Agricultural College, S. C.

International Yearbook of Forestry Statistics 1933-1935. Vol. II—America. By Ernest Palmgren and Nestor Smal-Stocky (under the direction of Valentine Dore). *xi + 201 pp. International Institute of Agriculture, Rome. 1938. Price 30 lire.*

This volume follows the same general plan and form as the first volume, which dealt with Europe and the Soviet Union.[1] It consists of two parts: forest resources, and the trade in wood for the years 1930-1936. For some of the countries, for which official statistics are meager, these are supplemented by descriptive notes drawn from the most reliable sources. As stated in the introduction, there are many gaps and inaccuracies in the existing statistics, and the matters covered by the forest statistics of the various countries are so heterogeneous that there is little comparability between one country and another.

The compilers are to be commended for having done a difficult job so well. Their work makes the *Yearbook* a handy reference source for those seeking up-to-date statistics on forest resources and timber trade.

W. N. Sparhawk.

Soil Profile Characteristics of the Pine-Growing Soil of the Coastal-Plain Region of Arkansas. By Lewis M. Turner. *Arkansas Agric. Exp. Sta. Bull. 361. 52 pp., 8 fig. 1938.*

This is a study of loblolly and shortleaf pine growth on twenty-two soil types in eastern Arkansas. Best growth of both species occurred on well-drained soils with an adequate water supply.

Significant positive correlation was disclosed between site index and depth of B_1 horizon, and significant negative correlation or a negative trend between site index and clay percent of the B_1 and B_2 horizons. The deeper B horizons may contain the lower percentages of clay. Often illuviation in a widely fluctuating zone of water-table level develops a more pervious subsoil than where deposition is concentrated in a narrow zone. That positive correlation between B horizon depth and growth accompanied negative correlation between clay content and growth is not at all inconsistent; in fact, it further emphasizes the deleterious effects of a dense subsoil on tree growth through impedance of water and air movement.

The gist of the bulletin is that the author has been able to analyze and classify groups of soil types on the basis of those physical properties which contribute to adequate moisture supply and aeration and to establish a definite relation between soil type and growth response.

No definite relation was observed between growth content of the soil, and pH or nitrogen and phosphorus except that soils excessively low in those elements did not produce best tree growth.

This study, involving such an array of variables, presents difficulties not encountered in investigations under controlled conditions. The author's grouping of soil types on the basis

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[1]Reviewed in July 1937 issue of the Journal.

of recognized physical properties and his demonstration of the relations of soil type to tree growth deserve commendation. This work should serve as a stimulus for similar investigations in other forested areas.

JOHN T. AUTEN,
U. S. Forest Service.

Big Trees. By Walter Fry and John R. White. *126 pp. Illus. Stanford Univ. Press. Stanford University, Calif. 1938. $1.50.*

The Sequoias, whether of the coast redwood forest or the isolated groves of big trees of higher elevation in California, seldom if ever fail to excite the viewer's interest. imagination, and wonderment. They are capable of stirring one deeply, as the following passage from *Big Trees* illustrates; at the same time it furnishes a vivid description of the coast redwoods. "Over Mr. Hergesheimer the coast redwoods threw a spell which he has forever embalmed in magical spices of words. . . . Standing in a grove I thought of the bitter and vain resentment that the future—when it had learned that a commerce was not enough to keep the heart alive—would hold against the past, our present. The grace of the towering trees masked their gigantic span; the ground, in perpetual shadow, held only flowering oxalis in emerald ferns. It was raining softly. The fallen trunks of an utter remoteness, too great to see over, were green with moss. The whisper of the wind was barely audible, far off, reflective; the gloom in the trees was clear, wet, and mild. It was the past. And this was the redwoods' secret, their special magic, that they absolved, blotted out the fever of time, the wasted years, the sickness of mind, in which men spent the loneliness of their lives."

Big Trees is mostly about the Giant Sequoias or big trees, although on many occasions they are compared to their cousins the coast redwoods. The story of big trees is written from many angles, such as their discovery, their naming, saving them from extinction by the ax, and their place in geologic history. Information is given on regeneration, size, age, distinguishing characteristics of bark and foliage, and mortality, much of which was gained through observation and study by the senior author. No claim is made by the authors to an exhaustive treatise, rather it has been prepared especially for the visitors to the big tree national parks and forests which have "increased many fold in the past few years, from a few hundred to hundreds of thousands." It is eminently suited to that purpose and should prove welcome, too, to the broad class of readers who have not or cannot visit the parks and forests but who are interested in conservation, natural history, and our recreational resources and wish to know something about the sequoias. In fact, the popularity of the book is somewhat attested to by its having been through three printings already before the present revised edition.

V. L. HARPER,
U. S. Forest Service.

Forestry Facts about the Tennessee Valley. A Preliminary Summary of Factual Data on the Extent, Character, Value, and Use of Forest Resources of the Tennessee Valley. *48 pp. Illus. Tennessee Valley Authority Dept. of Forestry Relations Bull. 2 (Processed). 1938.*

This modest bulletin provides a concise account of forest conditions in the Tennessee Valley. It also indicates what the Department of Forestry Relations is doing about the situation, and closes with a plea for serious cooperation and appraisal of the forest-land management problems by those public and private groups who profess themselves to be interested in the solution of these problems. Can this be irony?

The following comments may be of interest as an indication of what the bulletin has to offer and also of what is still left to the readers' power of deduction.

Knowledge that the nation-wide Forest Survey has to date covered only 30 percent of the Valley might constitute one reason for the above-mentioned plea for serious cooperation.

With ownership such a dynamic force in forest-land management one might expect from this book at least an inkling of future trends in public ownership; that is, beyond the statement that many proposals have been made for increasing federal, state, and local holdings.

In erosion control, fire control, and wildlife

development work it appears that the Forestry Relations Department is making satisfactory progress.

This report estimates that the average forest acre in the Tennessee Valley produces only 60 board feet of saw timber annually, of which some 35 percent is pine and 43 percent oaks and hickories. "In general," it says, "this region is faced with the rapid depletion of saw timber supplies" (and a corresponding increase of largely nonmarketable cordwood). Endangered by this troublesome trend are about one-fourth of all industrial workers in the Valley—not to mention most of its farmers!

Speaking of farmers brings to mind the fact that annual fuelwood production in the Tennessee Valley is valued at more than $23,000,000; that of the total annual wood production fuelwood makes up two-thirds, and that it represents a direct benefit or saving to more than 300,000 families. A few foresters might question the basis here, but the aggregate benefits could be much less and still be huge.

Getting back to labor returns: "At present the annual returns to labor from utilization of the Valley's timber resources are, roughly, $40,000,000. Under proper management this return could possible be increased to $100,000,000." Between that 40 and 100 million is a long story, yet to be told.

Perhaps as a prelude to the story on how to achieve this acme of forest-land management in the Tennessee Valley, the Regional Studies Section might dwell at length in their next publication on the actual and probable effects of forest-land misuse.

Lyall E. Peterson,
U. S. Forest Service.

Forestry and State Control. By R. S. Troup. *vi+87 pp. The Clarendon Press, Oxford, 1938. (Oxford Univ. Press, 114 Fifth Ave., New York). $1.35.*

This book, I believe, should have been written by an American forester; and it should have been published right now while the Joint Congressional Committee is at work.

True, in analysing and exemplifying the problems connected with the theme, no American could have done better than R. S. Troup who has watched those very problems with open eyes for almost fifty years.

After a brief review of the classes of forest ownership now existing and after a few words on the world's timber resources, there are five capital pages answering the question: "Is state control justified?" Then, after discussing the possibilities of assistance by the nation to the private owners of forests, the author describes the actual measures of control now existing in ten European countries; an average of four pages is devoted to each of them.

We cannot, of course, transfer to America any of those European systems because all constitutional and—which is worse—all economic conditions are at variance betwen here and there. Forestry, sustained as well as not sustained, is the outcrop of commonsense applied to *local* woods-conditions. But we can do the next best thing: We can read Troup's capital book, gaining from it an insight which is not obtainable from any other sources known to me, unless it be gained at a great outlay of time and of money for study and for travel.

C. A. Schenck,
Darmstadt, Germany.

Southern Forestry. By Charles N. Elliott and M. D. Mobley. *xi+494 pp. Illus. Turner E. Smith & Co., Atlanta, Ga. 1938. Pr. $1.60.*

In a number of southern states there is a growing demand that the public schools offer appropriate forestry instruction. Progress in this direction has been hastened by authors Elliott and Mobley, who have prepared *Southern Forestry* in an effort to meet the need for a suitable text devoted principally to the facts and problems of forestry in the South. Mr. Elliott, a forester, is director of state parks for Georgia, and Mr. Mobley is director of vocational education for the same state. Their book has already been adopted by the State Board of Education and will be made available as a free textbook to the state's public schools. Judging from endorsements by leaders in public instruction in many states, it appears destined to have wide use, particularly in vocational work and as a reference text in high schools. The edition now on the press will run into 40,000 copies.

According to the foreword, the text was written for use at the upper elementary grade level and was designed to be helpful to students having the opportunity to engage in practical forestry, and to others, particularly students in city schools, interested in developing an appreciation of forestry. The material is arranged in eight teaching units, each having from two to five chapters. Several pages of questions and problems, suggested activities, and selected references follow each chapter. These are carefully prepared and will aid greatly in discussion and further study of the material presented. The book is illustrated with 158 photographs and there are also 65 charts and tables. The cloth binding, good paper, and large type combine to make an attractive and serviceable printing job.

Of the nation's six forest regions, four are represented in the South, but, as would be expected, this book deals mainly with the important southern forest region. Its usefulness is by no means limited to this area, for many of the principles brought out have general application and may well be illustrated in this region of high productivity and fast-moving developments. Despite its length the book does not give a particularly detailed treatment of the subject, as much of the space is taken by illustrations and study helps. The authors follow the method of enlarging upon what they consider to be the main things. The subject matter is presented in simple, nontechnical language that will be readily understood at the grade level intended. The book has a decided lean toward the popular side and will no doubt be much read outside of schools. A surprisingly full store of up-to-date facts and figures makes it exceedingly useful to foresters who want a ready source of information on the forest situation in the South.

Foresters will recognize in *Southern Forestry* an outstanding work of its kind; they will also find it susceptible to a number of criticisms. Some phases of the subject do not appear to receive attention commensurate with their importance. For example, the chapter on cutting methods has only 10 pages, although improper cutting is probably the number-one evil in southern woods. A more adequate discussion, with arguments against short-sighted practices that are all too common, could well have been included. The 45 pages given to the chapter on forestry and recreation, in which nearly 200 parks and recreation areas are described, seem an overtreatment, considering the scope of this book. It may be questioned if the chapter headed "Naval Stores Outlook" is well adapted to the level of the book. Also, a key map referred to several times was omitted here.

There are a few errors, and some statements that do not appear to be well considered. For example, white pine is referred to as having more than five needles to the bundle. In one place the pulp and paper companies in the South are estimated to own 5,000,000 acres of timbered land, in another place the figure is set at 4,000,000 acres. The statement is made that the period of exploitation has passed. The authors could hardly take a trip of any length in their own State of Georgia, or in other southern states, without observing, in the continuing treatment of soil and forests, evidence to put this viewpoint in doubt.

These shortcomings and others that could be mentioned are completely overshadowed by the real worth of this text. It would be hard to find any book on forestry that develops the subject in such an interesting manner. Persons starting to look it over casually will quickly become engrossed. Attractive, readable, and informative, *Southern Forestry* is a valuable contribution to forestry advance in the South.

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